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US Army Corps
of Engineers
Sacramento District
South Pacific Division

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Sacramento Metropolitan Area, California

Reconnaissance Report

February 1989

Month Day Year

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RECONNAISSANCE REPORT

SACRAMENTO METROPOLITAN AREA, CALIFORNIA

February 1989

(Revised April 1989)

Department of the Army
Sacramento District, Corps of Engineers
Sacramento, California

SYLLABUS

The primary objectives of this study are to identify the level of flood protection provided by existing projects in the Sacramento metropolitan area not included in the American River Watershed Investigation, identify potential alternatives to increase that level of flood protection, and determine whether it is appropriate to proceed into feasibility studies.

The study area includes the developed areas along the Sacramento River and Yolo Bypass from the Fremont Weir downstream to an area just south of Freeport. In February 1986, major storms in northern California caused record floodflows in the Sacramento River Flood Control System. Based on flood emergency operations, levee embankment erosion and peak flood stage observations, the study area is at great risk from levee failure and overtopping during similar or larger flood events. Estimated residential, commercial and industrial damages could be as high as $1 billion and because of sudden or unexpected levee failure there is a potential for loss of life.

The alternatives that were evaluated to increase the level of flood protection include modifying Fremont Weir and Yolo Bypass, modifying Sacramento Weir and Bypass, diverting floodwaters into the Sacramento River Deep Water Ship Channel, modifying levees around West Sacramento, and removing flow constrictions from the Yolo Bypass. Study results indicate that modifications to Fremont Weir and Yolo Bypass and levee improvements for the West Sacramento area are economically feasible. Also, modifications to the Sacramento Weir could be potentially feasible and warrant further study. The Reclamation Board (State of California) has indicated their support for pursuing feasibility level studies of these alternatives. Based on prior coordination with South Pacific Division, Corps of Engineers, feasibility studies of the Fremont Weir alternative are being transferred to the American River Watershed Investigation. The Reclamation Board concurs with this transfer. Therefore, it is recommended that feasibility phase studies for the Sacramento Metropolitan Area Investigation be conducted and, focus on levee improvements for West Sacramento and modifications to the Sacramento Weir. In addition, feasibility studies should continue evaluating the level of flood protection for the south Sacramento area adjacent to the Sacramento River to assure that refinements to the study hydrology will not significantly affect previous judgements.

RECONNAISSANCE REPORT

SACRAMENTO METROPOLITAN AREA, CALIFORNIA

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CHAPTER I - INTRODUCTION

STUDY AUTHORITY

This study was conducted under the authority of the Flood Control Act of 1962 (Public Law 87-874), a portion of which reads as follows:

"The Secretary of the Army is hereby authorized and directed to cause surveys for flood control and allied purposes, including channel and major drainage improvements, and floods aggravated by or due to wind or tidal effects, to be made under the direction of the Chief of Engineers, in drainage areas of the United States and its territorial possessions, which include the following named localities: Sacramento River Basin and streams in northern California draining into the Pacific Ocean for the purposes of developing, where feasible, multi-purpose water resource projects, particularly those which would be eligible under the provisions of Title III of Public Law 85-5001."

PURPOSE AND SCOPE

The purposes of this reconnaissance study were to (1) identify the level of flood protection provided by existing projects, (2) evaluate the need for additional flood protection in the study area, (3) determine if there is a Federal interest in at least one flood control alternative, and (4) determine whether planning should proceed into a feasibility phase based on preliminary appraisal of Federal interest, costs and benefits and environmental impacts of potential alternatives. The study area includes the developed areas along the Sacramento River and Yolo Bypass from the Fremont Weir downstream to an area just south of Freeport.

PRIOR STUDIES AND REPORTS

Prior reports of primary importance to the Sacramento metropolitan area study are summarized in Table 1. Each report provided background information on the water resources and opportunities in the study area. In addition, several ongoing studies relate specifically to the formulation and evaluation of potential flood control alternatives along the Sacramento River.

EXISTING WATER RESOURCES PROJECTS

Federal

Central Valley Project. - The Central Valley Project (CVP) was authorized for construction in 1937. Constructed and operated by the U.S. Bureau of Reclamation (USBR), the CVP is a multiple-purpose development that stores and transfers surplus waters primarily from the Sacramento and Trinity River basins to the water-deficient lands of the San Joaquin River and Tulare Lake basins. Although the main function of the CVP is water supply, it also provides benefits to power, flood control, navigation, fish and wildlife, recreation, and water quality control. The physical features of the CVP include dams and reservoirs, pumping plants, canals and generating facilities.

TABLE 1

WATER RESOURCES STUDIES AND REPORTS ON THE SACRAMENTO RIVER

AGENCY	TITLE AND DATE	PURPOSE
Federal U.S. Army Corps of Engineers, Sacramento District	Definite Project Report, Sacramento River Deep Water Ship Channel Project, Sacramento River, California, July 1949.	Described the adopted project plan, with details of the basis of design and cost estimates.
	Report on American River Flood Plain, California, March 1963.	Presented data on the flood plain of the American River downstream of Folsom Dam. Intended to assist local agencies and individuals to plan and regulate future development in the flood plain in order to minimize flood damages and hazards.
	Cache Creek Basin, California, Feasibility Report and Environmental Statement for Water Resources Development, February 1979.	Investigated flood, sediment and related water resource problems and needs of the Cache Creek basin. Described and evaluated various alternatives to help solve these problems.
	Sacramento River and Tributaries, Bank Protection and Erosion Control Investigation, Sediment Transport Studies, rev. August 1983.	Described and evaluated potential erosion control measures that could be used in the Sacramento River basin. Determined sediment deposition in Yolo and Sutter Bypasses.
	Special Study on the Lower American River, California, March 1987.	Reviewed and updated the hydrology of the American River, determined areas of potential flooding, computed flood damages and benefits, and reviewed alternative measures for flood control.
	Report on the February 1986 Floods in Northern California and Northwestern Nevada, January 1987.	Documented the hydrologic, physical and economic damage data of the February 1986 rainfloods that occurred in Northern California and Northwestern Nevada.
	Information Paper, American River Watershed, California, November 1987.	Summarized the results of the American River Watershed Reconnaissance Study.
	American River Watershed Investigation, California, Reconnaissance Report, January 1988.	Defined flood problems in the watershed. Formulated and evaluated alternative plans for flood control along the lower American River and in the Natomas area.
	Sacramento River Deep Water Ship Channel, California, Supplement No. 1 to the General Design Memorandum of March 1986, May 1988.	Investigated redesign of the ship channel in order to reduce project costs. Emphasized channel width requirements, dredged material quantities and disposal areas, and operation and maintenance considerations.

TABLE 1 (continued)

WATER RESOURCES STUDIES AND REPORTS ON THE SACRAMENTO RIVER

AGENCY	TITLE AND DATE	PURPOSE
Federal U.S. Army Corps of Engineers, Sacramento District	Sacramento River Flood Control System Evaluation, Initial Appraisal Report - Sacramento Urban Area, May 1988.	Investigated the structural integrity of about 110 miles of Sacramento River Flood Control Project levees in the Sacramento urban area.
	Dry Creek (Roseville), California, Interim Investigation, Draft Feasibility Report and Draft Environmental Impact Statement, September 1988.	Investigated water resource related problems in upper Dry Creek basin. Formulated and evaluated alternative plans for flood control and recreation in the Roseville area.
	American River Watershed Investigation, Feasibility Study, pending completion October 1990.	Further define flood problems in the watershed. Formulate and evaluate detailed alternative plans for flood control along the lower American River and in the Natomas area.
Federal Emergency Management Agency	Sacramento Flood Insurance Study, January 1989.	Prepared a Flood Insurance Rate Map showing the 100-year (FEMA base) flood plain. Includes the American River downstream of Nimbus Dam, North and South Natomas, and the Sacramento River from the Natomas Cross Canal downstream to Freeport.
	West Sacramento Flood Insurance Study, pending completion May 1989.	Develop a Flood Insurance Rate map that will show the 100-year (FEMA base) flood plain. Includes the west side of Sacramento River from Fremont Weir downstream to the southern limit of West Sacramento.
U.S. Geological Survey	Profile of Sacramento River, Freeport to Verona, California, Flood of February 1986, Open-File Report 88-82, 1988.	Documented the February 19 and 20, 1986, peak water-surface profile of the Sacramento River, peak discharges of the Sacramento Sacramento and American Rivers, and data for five gaging stations located in a 33-mile reach between Freeport and Verona.
State of California	Report to the Trustees of the American River Flood Control District on Flood Control of the American River, December 1929.	Discussed flooding problems along the American River, particularly the March 1928 flood. Presented designs, costs and benefits of a plan to alleviate future flooding.
DWR	A Preliminary Study of Flood Control Alternatives on the Lower American River, September 1982.	Evaluated five alternative means of providing greater flood protection along the American River below Folsom Dam. Recommended that additional flood control studies focus on structural modifications and revised operational criteria for Folsom Dam.

TABLE 1 (continued)

WATER RESOURCES STUDIES AND REPORTS ON THE SACRAMENTO RIVER

AGENCY	TITLE AND DATE	PURPOSE
County of Sacramento	Multi-Hazard Functional Plan, pending completion February 1989.	Discussed procedures to be followed during various emergencies (including flooding and dam failure) in the County.
City of Sacramento	Emergency Plan, October 1986.	Outlined procedures to be followed during various emergencies (including flooding) involving the personnel of the Public Works Department.
	Drainage Study, North Natomas Area, Phase II, December 1987.	Evaluated various alternatives and recommended a plan to provide drainage of storm water from the area contained in the North Natomas Community Plan.
Private		
Frank Kochis	History of Development of the Sacramento River Flood Control Project, July 1969.	Presented a historical survey of the legal documents and political events leading to the construction and implementation of the Sacramento River Flood Control Project.
Ray Krone	Impacts of the Lighthouse Marina Project on Flood Flows, August 1986.	Evaluated the impacts of the Lighthouse Marina project on the capacity of the Sacramento and American Rivers to convey flood-flows.

The main source of CVP project water is Shasta Reservoir, which was completed in 1943. The reservoir stores 4.5 million acre-feet (af) of water, and during the rainflood season, 1.3 million af are reserved for flood control. Regulation and operation of the CVP reservoirs for flood control are established by cooperative agreement between the USBR and the Corps of Engineers (Corps).

Folsom Lake is located on the main stem of the American River 20 miles upstream from Sacramento near the town of Folsom. The project consists of a concrete gravity main dam, wing dams, and 8 earthfill dikes, creating a reservoir with a storage capacity of one million af. Construction of Folsom Dam and Reservoir was completed by the Corps in 1956. After completion, operation and maintenance of the Folsom facilities were transferred to USBR as part of the CVP. The project provides 400,000 af of authorized flood control space, 500,000 af of water for irrigation and municipal uses, and 500 million kilowatt-hours of hydroelectric power annually.

Sacramento River Flood Control Project. - The Sacramento River Flood Control Project was authorized by the Flood Control Act of 1917. Construction began in 1918 on this local cooperation project sponsored by The Reclamation Board, and the various components were completed between 1952 and 1958. The project consists of a comprehensive system of levees, overflow weirs, outfall gates, pumping plants, leveed bypass floodways, overbank floodway areas, enlarged and improved channels, and dredging in the lower reach of the Sacramento River.

The project includes approximately 980 miles of levee construction (including 170 miles of levees on the Feather River and tributaries) providing flood protection to about 800,000 acres of agricultural lands; the cities of Colusa, Gridley, Live Oak, Yuba City, Marysville, Sacramento, Courtland, Isleton, Rio Vista, and numerous smaller communities; two transcontinental railroads; feeder railroads; and many state and county highways. The project has prevented billions of dollars in flood damage during its history.

During major floods, the containment of floodflows in leveed channels on the valley floor is possible because the initial surges of runoff are detained in foothill reservoirs. At the same time, full benefits of the reservoirs would not be realized if specific downstream channel capacities were not provided and maintained.

Operation and maintenance of the project is the responsibility of local interests.

American River Flood Control Project. - The American River Flood Control Project was constructed by the Corps in 1958 and is operated and maintained by the Department of Water Resources (DWR). The project consists of a levee extending from high ground near Carmichael downstream along the north side of the American River to a previously existing levee ending near the Interstate Business 80 crossing, a distance of about 7 miles. Two pumping plants are part of the project, and they discharge into the river to dispose of storm drainage collecting in low areas landside of the levee. In conjunction with Folsom Lake, the levee permits design releases of 115,000 cubic feet per second (cfs) for flood control along the river downstream.

Black Butte Dam and Reservoir. - The Black Butte Dam and Reservoir was constructed by the Corps in 1963. The project consists of an earthfill dam, six earthfill dikes, and a lake with a gross capacity of 144,000 af. The authorized flood control space in the reservoir is 137,000 af.

Sacramento River Deep Water Ship Channel. - The Sacramento River Deep Water Ship Channel (Ship Channel) was completed in 1963; the Sacramento-Yolo Port District is the sponsor of this local cooperation navigation project. The 43-mile channel was formed by widening and deepening existing channels from Suisun Bay to Rio Vista, and by excavating a new channel from that point to Lake Washington near Sacramento. The project also includes a triangular harbor and turning basin in Lake Washington and a shallow-draft barge canal with a navigation lock between the harbor and the Sacramento River.

The 1.5-mile barge canal and lock provide for transfer of barges between the two different water surface elevations. The lock is 86 feet wide and 600 feet long and has a 4-foot lift at normal pool elevation. A 135-foot span single leaf combination highway and railroad bascule bridge crosses that canal at the harbor end of the lock.

The lock is currently in "caretaker" status under Corps jurisdiction. The lock is permanently closed except in emergency or special situations. State and local agencies have expressed interest in reactivating the lock; however, future operation is still uncertain.

State of California

California State Water Project. - In 1959, the State Legislature enacted the California Water Resources Development Bond Act, which authorized the construction and operation of the State Water Project (SWP). The SWP facilities include 23 dams and reservoirs, 8 powerplants, 22 pumping plants and 684 miles of aqueducts. These facilities are designed to readjust the imbalance of California's water resources and water needs.

The major feature of the SWP is Oroville Lake, located 4 miles northeast of the city of Oroville. Oroville Dam was completed in 1967 and is the highest earthfill dam in the United States. The dam impounds a 3.5 million-acre-foot reservoir, 750,000 af of which are reserved for flood control. Flood control operations are coordinated with New Bullards Bar Reservoir on the North Fork of the Yuba River according to rules prescribed by the Corps.

Local

New Bullards Bar Reservoir. - New Bullards Bar Reservoir was completed in 1971 by the Yuba County Water Agency and consists of a concrete arch dam, a 960,000-acre-foot reservoir, and 2 powerhouses. The project is located on the North Fork of the Yuba River about 30 miles northeast of the city of Marysville. The project was built for irrigation, power generation, recreation, fish and wildlife enhancement and flood control. Storage capacity for flood control is 170,000 af. Flood control operations comply with rules and regulations prescribed by the Corps.

Levees. - Several non-Federal levees exist throughout the Sacramento metropolitan area, including road and railroad embankments that generally would function as barriers to floodflows during major flood events. These levees and embankments could impact flood stages and flooded areas within the Sacramento area.

There are two significant private levees in the study area. The first is located along the southern limit of West Sacramento. This reclamation levee, about 1.2 miles in length, connects the Sacramento River Flood Control Project levee on the east and the Yolo Bypass levee on the west and can restrict the area of potential flooding to West Sacramento. The minimum crown elevation is about 24.5 feet. Levee embankment strengths determined under the Corps' Sacramento River Flood Control System Evaluation (1988) are probably adequate to provide stability under existing conditions and for levee raising. The second levee embankment is located adjacent to the lock and barge canal on the south side and provides a measure of flood control to the area of West Sacramento south of the Port of Sacramento (Port).

Drainage Facilities. - Within the areas protected by the Sacramento River Flood Control Project levees and other local levees, a system of canals are used to collect and channel surface water runoff from rainfall, irrigation, and other sources into pumping stations located near the levee embankments. The pumps are then used to pump water through the levee embankments into the Sacramento River, Yolo Bypass, Ship Channel, Natomas Cross Canal and other tributaries that make up the Sacramento River Flood Control Project system. Pumps are needed because water surface elevations on the Sacramento River, Yolo Bypass, etc., during major flood events are significantly higher than adjacent land surface elevations landward of the levees. In addition, because the sump areas for the various pump stations have limited capacity, pumps run at or near peak capacity during major rainfall events in an effort to remove accumulated runoff.

Interior drainage and pumping of surface water runoff within West Sacramento are primarily the responsibility of Reclamation Districts 537 and 900. Peak pumping capacity of these districts is about 500 cfs, and pumped water is diverted into the Sacramento Bypass, Yolo Bypass and the Ship Channel. In addition, other local landowners pump much smaller quantities into the Sacramento River.

Reclamation District 1000 is primarily responsible for interior drainage in the Natomas area. Pumping capacity is about 2,100 cfs, and about 300 cfs of this amount could be pumped into the Natomas Cross Canal and about 1,200 cfs into the Sacramento River.

The City and County of Sacramento, Sacramento Regional Wastewater Treatment Plant, various other Reclamation Districts and local entities pump from 100 to 2,000 cfs of water into the Sacramento River Flood Control Project system. With future development in West Sacramento and the Natomas area, the pumping capacities are expected to increase.

City of Sacramento Floodgates. - The City of Sacramento's emergency plan includes a number of permanent and portable floodgates. The gates are located at railroads, streets, bike trails/pedestrian paths, and floodwalls where they create low points, or subways, in the levees. The plan provides for all these

gates to be erected or closed under specified conditions. Facilities for installation of floodgates on Arcade and Dry Creeks, the Natomas East Main Drainage Canal and the Old Sacramento Riverfront were constructed following the 1986 flood.

Various types of floodgate structures are used. They include large metal doors, wooden planks, steel beams, large wooden doors and "A" frames.

AUTHORIZED AUBURN DAM PROJECT

The Auburn-Folsom South Unit of the CVP was authorized in 1965 under Public Law 89-161. The unit includes Auburn Dam, Reservoir and Powerplant on the North Fork American River above Folsom Reservoir; Folsom South Canal; Sugar Pine Dam, Reservoir and conveyance; and County Line Dam, Reservoir and conveyance. The currently authorized Auburn Dam would be about 653 feet high and impound a reservoir of 2.3 million acre-feet. When operated with Folsom Reservoir, it would provide a high level of flood protection to the Sacramento area.

Currently, Sugar Pine Dam and Reservoir and two reaches of the Folsom South Canal have been completed. Construction of the Auburn Dam began in 1967. By 1975, the Auburn Dam diversion tunnel and the cofferdam were completed, and work was underway on the main dam foundation. In 1975, however, the Oroville earthquake occurred, and construction of the dam and powerplant was suspended pending further seismic evaluation. In 1980, the Auburn Dam was determined to be seismically safe, but construction was delayed until downstream flow issues were resolved.

To date, no non-Federal project sponsor has been identified, and construction of the Auburn project has not been resumed.

EMERGENCY PREPAREDNESS PLANS

Federal

Corps of Engineers. - The Sacramento District responds to a flood emergency by going into three phases of readiness. The Informational Phase refers to a situation of potential flooding. During this phase, hydrological elements of the Sacramento District are on 24-hour informational status and begin 24-hour liaison with State Flood Operations Center(s). The Alert Phase is initiated when a flood situation is or will become a threat to life or property. The Corps' Emergency Operations Center (EOC) is activated during this phase. Corps' office and field personnel, in cooperation with emergency teams of the affected State, begin patrol and observation activities. The Mobilization Phase is a period when major flooding appears imminent or is occurring and the Sacramento District is requested to furnish or is providing emergency assistance.

Emergency assistance activities include repairing levee breaks, placing riprap along levees, placing material on levees to prevent overtopping, constructing additional protective levees, and providing sandbags.

State of California

The State-Federal Flood Operations Center, in cooperation with the National Weather Service California-Nevada River Forecast Center, monitors weather and river information and other data around the clock during the rainy season, and can provide early warnings of flood threats to local, State and Federal agencies. When the rivers begin to rise, the flood center puts out Federal-State forecasts of conditions, and staff makes warning calls to individuals and agencies so they can begin mobilizing levee patrols, moving equipment and livestock, and evacuating flood plain residents.

At the same time, the State Office of Emergency Services (OES) and County OES staffs are monitoring flood information and preparing to help people. The OES network includes fire departments, law enforcement agencies, and highway and road departments.

Local

County of Sacramento. - The County of Sacramento has a multi-hazard emergency plan that includes procedures to be followed during flooding and dam failure. Preparations for a slow-rise flood threat are organized into three stages based on river elevations at specific locations in the County. The County OES declares response stages after considering weather forecasts, dam releases and levee conditions. Each County agency has a list of actions to be taken during each stage of the flood threat. A dam failure initiates immediate action to save lives.

County of Yolo. - The County of Yolo has a similar multi-hazard emergency plan. Each County agency has designated responsibilities during an emergency, and an emergency center provides information and coordinates activities.

City of Sacramento. - The City emergency plan also includes procedures to be followed in a flooding situation. The Public Works Director coordinates activities from a City EOC. All City departments have specified responsibilities during pre-emergency, emergency and post-emergency (recovery) periods. Actions during a flood may include notifying and mobilizing personnel and resources, patroling levees, closing floodgates, coordinating activities with other Federal, State and local agencies, and assisting flood control districts maintain the integrity of local levees.

CHAPTER II - STUDY AREA DESCRIPTION

EXISTING CONDITIONS

Environmental Setting and Natural Resources

Study Location. - The study area is located in Sacramento and Yolo Counties near the cities of Sacramento and West Sacramento in the southeast portion of the Sacramento Valley (see Plate 1). The study area begins just upstream of the Fremont Weir at the confluence of the Sacramento and Feather Rivers and extends downstream to an area just south of Freeport. The Sacramento River forms the northern and eastern boundaries of the study area; the west levee of the Yolo Bypass forms the western boundary; and the cross levee shown in Plate 1 is near the southern boundary. A more detailed discussion of environmental resources can be found in the Environmental Information Paper (see Attachment).

Area Description. - The study area includes components of the Sacramento River Flood Control Project, including levees along the Sacramento River, Fremont and Sacramento Weirs, and Yolo and Sacramento Bypass channels. The Ship Channel and associated Port facilities are also located in the southern portion of the study area. Flows emptying into the Yolo Bypass include Knights Landing Ridge Cut, Cache Creek, Willow Slough and Putah Creek.

The area contains approximately 150 square miles of land. The Yolo Bypass contains about 40,000 acres (within the study area), the Sacramento Bypass 500 acres, and the West Sacramento area 13,000 acres.

Geology and Soils. - The study area is geologically part of the Great Valley Geomorphic province of California. The broad valley was filled with erosion debris that originated in the surrounding mountains. Most soils in the area are recent alluvial flood plain soils. They consist of unconsolidated deposits of clay, silt, and sand and occur as flood plain deposits. Fresh alluvium is deposited (particularly within the bypasses) with each floodflow.

Climate. - The Sacramento area has a mediterranean climate characterized by hot, dry summers and mild, rainy winters. Yearly precipitation averages 16 to 17 inches per year. Most of this precipitation occurs during the months of November to April.

Local meteorological conditions result from the topography of the valley. Winds are channelled by the mountain ranges that surround the valley so prevailing winds in West Sacramento are from the south and west. Air flow passes through the Carquinez Strait, bringing cool southerly winds from the ocean in the summer and rainstorms in the winter.

Air Quality. - The study area lies within the Sacramento Valley Air Basin, and pollutant sources are classified as urban. Federal air quality standards for ozone are being exceeded several times each year. Contributors to the regional ozone problem include motor vehicle emissions, pesticide use and non-highway mobile sources (boats, off-road vehicles and aircraft).

Water Quality. - Water quality of the Sacramento River is considered good, although it is affected by upstream agricultural discharges and runoff. These flows are highly turbid and contain pesticides and herbicides.

Water in the Ship Channel near the Port has a higher level of total dissolved solids than the Sacramento River because insufficient water moves through the lock to flush that portion of the channel.

Vegetation. - Vegetation in the study area includes various habitat types: mixed riparian forest, riparian scrub, valley grassland, valley oak woodland, willow scrub, and freshwater marsh.

Mixed riparian forest and riparian scrub form narrow, linear bands adjacent to the Sacramento River, the Old River channel near the Fremont Weir, Tule Canal, Knights Landing Ridge Cut, and various toe drains adjacent to the waterside of the levees (see Environmental Information Paper). Trees include oaks, sycamores, willows and cottonwoods; the understory is herbaceous, composed of grasses, blackberry, poison oak and wild rose. Emergent marsh, dense willow thickets, and cottonwoods are also supported in the Knights Landing Ridge Cut area. Near the Sacramento Bypass are areas of open water that contain some emergent marsh vegetation.

The central part of the Yolo Bypass is farmed, and riparian vegetation is confined to canals and toe drains. Putah Creek empties into the Yolo Bypass on the west side; at the creek's terminous there are areas of riparian scrub and forest.

Land in the West Sacramento area is used for agricultural, industrial and residential purposes, and riparian vegetation is limited to drainage ditches. The levee adjacent to the east side of the Ship Channel is sparsely vegetated with grasses and forbs.

Fisheries. - The Sacramento River provides important spawning and rearing habitat for an abundant and diverse variety of both anadromous and resident species of fish. Anadromous species include striped bass, steelhead trout, American shad and chinook salmon. Resident species include catfish, black bass, largemouth bass, black crappie, warmouth, Sacramento squawfish, and Sacramento sucker.

When floodflows of the Sacramento River are diverted into the Yolo Bypass and Sacramento Bypass at the weirs, fish species that inhabit the River are diverted into the bypasses. When flows recede, depressions within the bypasses form temporary pools, and fishes not flushed out are stranded. Because of the intermittent nature, the bypass areas do not support permanent fish populations. However, the canals and toe drains do provide year round habitat for warm water species such as carp and catfish.

The Ship Channel supports anadromous sport species such as the king salmon, striped bass and steelhead. Resident species include the channel catfish, brown bullhead, and sunfish.

Wildlife. - Wildlife species are associated with the type of habitat available for food, cover and nesting. Riparian forest, valley oak woodland and freshwater marsh areas are highly productive wildlife areas. Species

found in these areas include house finch, scrub jay, acorn woodpecker, egret, owl, red-tailed hawk, Swainson's hawk, Virginia opossum, gray fox, raccoon, western gray squirrel and muskrat. During the winter months the Yolo Bypass is used by migratory waterflow and raptors.

The open grassland and riparian scrub areas are used by species that feed on seeds and vegetation. Examples include the California ground squirrel, California vole, California quail and American goldfinch. Vertebrate predators include the gopher snake, red-tailed hawk and striped skunk.

Agricultural fields provide foraging areas for species such as the red-tailed hawk, Brewer's blackbird and black-tailed hare. These species often nest in nearby riparian areas and use agricultural fields and annual grassland for feeding.

Rare, Threatened and Endangered Species. - There are no Federally endangered plant or animal species known to exist in the area. However, there are several Federal candidate species: Swainson's hawk, Tricolored blackbird, and California Hibiscus. The bank swallow, which is protected under the Migratory Bird Treaty Act, is also found in the study area.

Fish species that have been recommended for the Federal candidate list are the Sacramento perch and the Sacramento splittail. In addition, the giant garter snake, a State threatened species and Federal candidate species, and the threatened valley elderberry longhorn beetle may occur in the study area.

Socioeconomic Conditions

The study area is sparsely populated except for the city of West Sacramento, which had a population of about 27,500 in 1988. Incorporated in 1987, the City is projected to grow to 32,170 by 2000 and 36,102 by 2010 (estimates by the Sacramento Area Council of Governments). Population growth could be faster if infrastructure problems are solved. There are a few residences and businesses along the Sacramento River, but no residential, commercial or industrial development is allowed in the flood bypass areas.

Median household income in West Sacramento was $12,794 in 1980, and the median housing value in 1986 was $70,000. Unemployment was about 7.5 percent in 1980. Employment types include wholesale and retail trade, manufacturing, professional and agricultural.

The land use in the study area is largely agricultural, with some marina and residential development along the river. Also, several areas are managed as wildlife management areas or refuges by the State or private interests. In the city of West Sacramento, about 40 percent of the land is urbanized. This urbanized land is about evenly distributed between residential and non-residential uses. The City has the largest concentration of industrial development in Yolo County.

The Port is a major shipping installation for the Sacramento Valley. The area surrounding the Port is developing as an industrial district. The immediate vicinity has a significant amount of new facilities for small-scale industrial and research and development activities.

The study area is serviced by a number of regional and local roadways and railroads. Regional highway access is provided by Interstate 5 (I-5), Interstate 80 (I-80), and Business 80/U.S. 50. Railroads include the Southern Pacific Railroad (SPRR) and Union Pacific (UPRR). Local rail line spurs provide service to the industrial areas in West Sacramento.

FUTURE CONDITIONS

Future conditions in the bypass areas are expected to remain essentially the same. During nonflooding times of the year, the bypasses will continue to be managed as wildlife areas or farmed. In the West Sacramento area, major residential, commercial and industrial projects are planned for areas along the river, near the Port and in the Southport area. Proposed or committed projects include the Lighthouse Marina, Raley's Landing, Port Sacramento Industrial Park, Southport Industrial Park, and Newport Specific Plan.

CHAPTER III - PROBLEMS AND OPPORTUNITIES

FLOOD PROBLEMS

Historical Flooding

The climate and geography of the Sacramento Valley combine to produce an area where regular flooding is natural. Under natural conditions, the Sacramento River channel in the valley area had insufficient capacity to carry the heavy winter and spring flows generated by precipitation and snowmelt. Once flow exceeded channel capacity, channels overflowed into surrounding countryside. At the same time, eroded material from the mountain and foothill areas was deposited on the riverbed and valley floor.

Once agricultural development began in the area, the need for flood control became apparent. Landowners built private levees to protect specific tracts of land. These levees tended to increase depths of floodwater in other areas, which were further increased by the millions of cubic yards of hydraulic mining debris washed into valley streams between 1853 and 1884. By the 1880s, it was obvious that a coordinated plan of flood protection was needed for the Sacramento Valley.

Flooding during this time was common and widespread. Indian folklore and newspaper accounts mention at least nine major floods prior to 1900. Two of the earliest floods documented by newspaper accounts occurred in 1849 and 1862. The U.S. Geological Survey (USGS) kept gaged records of discharge during major flooding in March 1907 and January 1909, and the Corps used this information to make estimates of total discharges and flooded areas during these events. The 1907 flood was considered the "greatest experienced since the flood of 1862," and the design of the Sacramento River Flood Control System was based primarily on this 1907 flood. (Based on high water marks in the upper tributary basins, however, the peak flows of 1862 actually exceeded those of 1907 and 1909 at various locations in the Sacramento River watershed. These estimates also indicated that the 1862 storm had a greater intensity and duration than the later two events.)

The losses throughout the valley due to these early floods were large. Rivers everywhere overflowed their banks, and water, mud, sand and gravel swept over unprotected farmland and communities. Dry creeks became raging watercourses that converted lowland areas into shoreless lakes. Until flood waters subsided, transportation, business and farming came to a standstill. Estimated losses in 41 reclamation districts during the flood of January 1909 were over $4.5 million; losses during the March 1907 flood were somewhat larger. It was estimated that losses due to the floods of 1904, 1907 and 1909 amounted to at least $11 million.

Large floods since operation of Folsom Dam on the American River became effective include those in 1955, 1964, 1969, 1970, 1982 and the flood-of-record in 1986. Table 2 shows the approximate peak flows of these flood events on the Sacramento River at "I" Street.

TABLE 2

Estimated Peak Flows of Historic Flood Events
Sacramento River at "I" Street 1/

Date of Flood Event	Flow (cfs)
Dec. 1955	95,000
Dec. 1964	100,000
Jan. 1969	96,000
Jan. 1970	94,000
Dec. 1982	98,000 2/
Feb. 1986	117,000 2/

1/ Design flow of the Sacramento River at "I" Street is 110,000 cfs.
2/ Measurement taken downstream of "I" Street on the Sacramento River at Freeport.

Damages from these flood events occurred outside the study area when tributaries overflowed their banks, restricted flows backed up, and levees were overtopped and failed. Although there were no major flood damages in the study area during these events, high water conditions threatened to overtop levees and transportation lines, eroded levee embankments, and weakened the structure of levee embankments. On-site emergency work, including sandbagging and laying plastic sheets, was required to prevent levee overflow and erosion of levee embankment material due to wave action and floodflow.

February 1986 Flood of Record

State Wide Impacts. - The series of storms that struck California in February of 1986 resulted in the "flood of record" for many parts of northern and central California (for records generally dating back to the early 1900's). Major streams affected were the Sacramento, Feather, Yuba, American, Napa, Cosumnes, Mokelumne, Petaluma and Russian Rivers. Heavy rains and flooding continued for more than a week from the California north coast to the San Joaquin Valley. Precipitation totals for the 10-day storm were more than half of the normal year's supply of rain for much of California. The Sacramento region was in the center of the path of storms that originated in the Pacific, pushing the flood control system to its capacity and beyond.

The Sacramento River flood control system is characterized by a series of leveed river channels, weirs, and bypass channels that carry major flood flows. Successful operation of this system as a whole depends on the successful operation of its individual parts. In February 1986, much of the system was overloaded. Large reservoirs in the region such as Folsom, Black Butte, Pardee and Camanche were filled beyond their design capacity. Record flow releases from these and other reservoirs strained the downstream system of levees beyond that which they were designed to hold.

Record high flows saturated much of the levee embankment system, compromising the structural integrity of the levees, while severe winds often drove the waves over the top of the levee embankment. Emergency crews worked around the clock, patrolling and repairing damaged levees throughout the system. Levee breaks and/or the threat of levee failure led to emergency

evacuation procedures in many counties around the state including Sacramento, Sutter, Yuba, Placer, and several islands in the Delta. Near Rio Vista, California, floodwaters contributed to a high tide reading almost 2 feet higher than ever recorded.

Emergency levee work prevented catastrophic flooding in many places, including the Sutter Bypass levee near Robbins. However, in spite of diligent levee patrolling and emergency levee work, several levees failed in the 1986 flood. Levees failed on Yankee Slough in Sutter County, along the Yuba River opposite Marysville, and along several islands in the Delta.

Highway and road closures due to high water, slides and snow isolated many communities. An Eel River bridge at Rio Dell on the north coast collapsed as a crane removed debris jammed against its supports. I-5 from Sacramento to Lodi was closed for nearly 3 weeks.

When the storm was finished, the Governor had proclaimed emergencies in 39 counties and damages totaled more than half a billion dollars. Preliminary damage estimates from the State OES by county are shown in Table 3.

TABLE 3

Estimated Damages by County for February 1986 Flood

County	Damages in Millions of Dollars
Napa	50
Sacramento	49
Sonoma	40
Solano	27
Yuba	23
Sutter	20
Placer	16
Butte	15

Statewide flood damage estimates indicated that 12 deaths were attributed to this February 1986 storm along with 67 injuries, and more than 50,000 people were forced from their homes. Property damage included approximately 12,500 houses and 1,000 businesses damaged, and 1,400 houses and 200 businesses destroyed.

Regional. - The area being studied in this investigation is a portion of the greater Sacramento River flood control system. The following is a chronology of some of the events that took place during the February 1986 flood event that ultimately influenced our study area:

<u>January 31</u>

-Precipitation falls on much of the State nearly everyday until February 3.

February 11

-The first of the flood-inducing rainfall begins in the evening, peaking on February 12. The storm's origin is the Pacific just north of Hawaii.

February 12

-Flash flood warnings are given for some areas in the California coastal mountains.

February 13

-Another strong storm develops northeast of Hawaii, resulting in gusty winds and heavy rains through February 15 in central and northern California.

February 14

-The DWR Flood Operations Center and the National Weather Service California-Nevada River Forecast Center staff alert Federal, State and local authorities to ready emergency manpower and equipment for the crisis.

February 15

-River systems within the central California coastal ranges are flooded.

-Flash flooding occurs in the North Bay counties.

February 16

-A new storm system from Hawaii moves onto the coast, producing heavy rains from North Bay counties to the Sierra Nevada until February 17.

February 17

-There is widespread flooding, flash flooding and earth movement throughout northern California.

-Flooding and/or evacuation takes place in Napa, Sonoma, Santa Cruz, Calaveras, Tehama, Solano, and Santa Clara Counties.

-Yuba and Feather Rivers reach flood warning stages.

-Levee on Yankee Slough in Sutter County fails, and 20 people are evacuated.

February 18

-Another Pacific weather system approaches northern and central California with intensities close to a half inch an hour at Sacramento. This storm continues until February 21.

-Cofferdam at the Auburn site, upstream on the North Fork of the American River, gives way (as designed) adding 100,000 af of water to Folsom Lake.

-North of the American River, Dry Creek floods Rio Linda; 200 homes are evacuated.

-Boils are seen forming behind the American and Sacramento River levees. Emergency work includes sandbagging rings around boils to prevent levee failure.

-Sutter County declares a state of emergency as the Feather River near Marysville rises.

-Communities of Pleasant Grove and Elverta just east and north of Natomas flooded.

<u>February 19</u>

-Several islands in the Delta, south of Sacramento, are flooded due to levee failures along the Mokelumne River.

-The state fairgrounds and some apartment complexes are flooded in Sacramento. More than 700 people are evacuated and area-wide evacuation plans are readied.

-Arcade Creek floods parts of North Sacramento.

-Sections of Roseville are flooded by Dry and Linda Creeks.

<u>February 20</u>

-Although the Feather and Yuba Rivers are receding, the Yuba River levee fails opposite Marysville, and 24,000 people flooded out in the Linda-Olivehurst area.

-More Delta islands flood from the Mokelumne River.

-On the Sacramento River, Garden Highway levees show signs of weakening. Emergency crews move in to shore up and protect North Natomas.

<u>February 21</u>

-Boils and seeps continue to be found along the American and Sacramento Rivers. Several boils reported along the Garden Highway and in South Sacramento.

<u>February 22</u>

-A slump (400 feet long) is found on the Sutter Bypass levee near Robbins. Evacuations and emergency levee work thwart disaster.

-Precipitation slows to a stop, but high water will take weeks to abate.

Study Area. - Many of the northern tributaries to the Sacramento River flood control system had peak flows that were lower than the flow of record during the February 1986 flood event. Upstream of the study area, the

Sacramento, Feather and American Rivers had peak flows that indicated 10-year, 80-year and 70-year flood events, respectively. When these flows and local tributary inflow nearly coincided in the study area, peak flows and stages approached if not exceeded the system design levels. A photo of the Tower Bridge during the February 1986 event demonstrates the high water level and its proximity to the metropolitan area of Sacramento (see Figure 1).

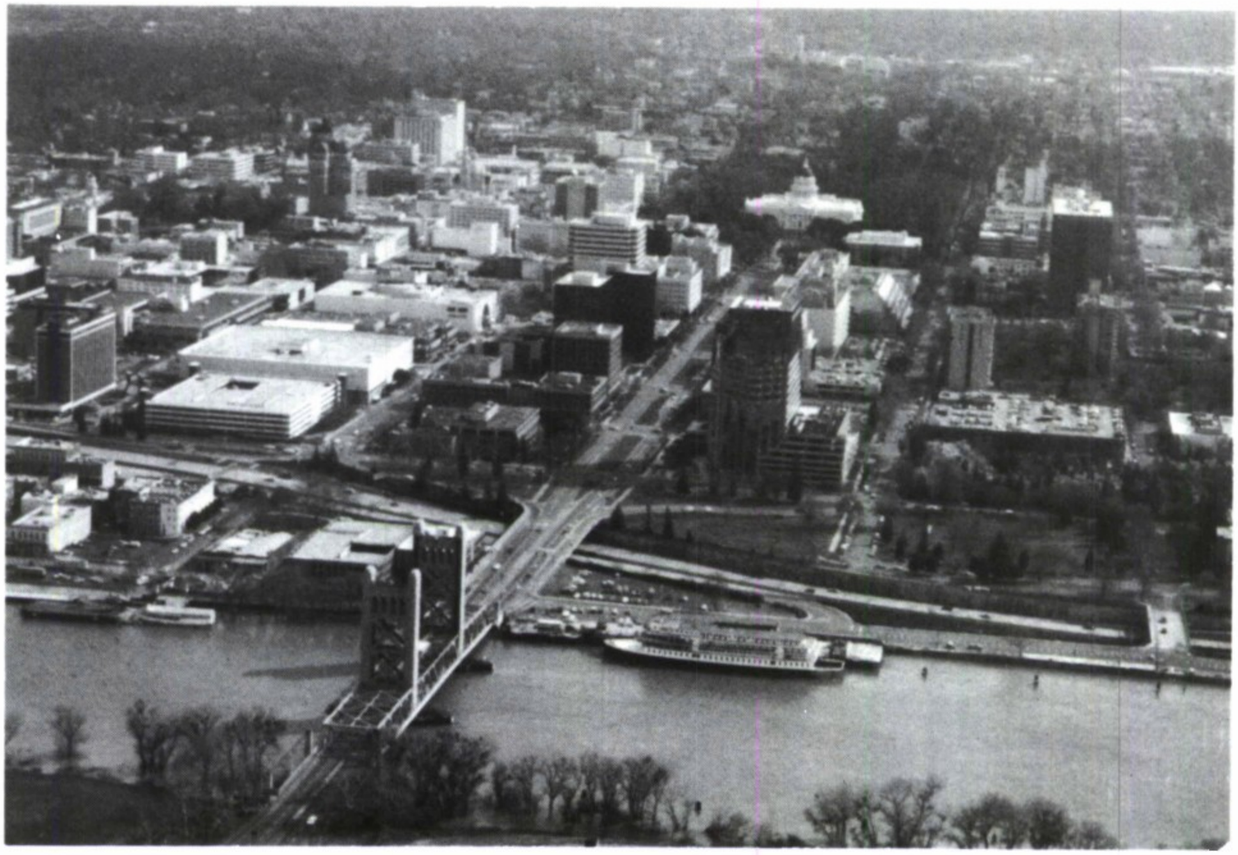
In February 1986, both Black Butte Reservoir on Stony Creek and Folsom Reservoir on the American River were surcharged. The resulting peak releases from Folsom were between 15,000 cfs and 20,000 cfs more than the downstream levee system was designed for.

The weir and bypass system was built to direct reservoir releases and uncontrolled runoff around main population centers in the Sacramento Valley. Within the study area, Fremont and Sacramento Weirs direct floodwaters from the Sacramento River to the Yolo Bypass, around the metropolitan areas of Sacramento and West Sacramento. During large floods, a portion of the American River flow moves upstream from the mouth of the American River along the Sacramento River channel to the Sacramento Weir, where it is diverted into the Yolo Bypass. In 1986, the estimated peak flow over Sacramento Weir exceeded the project design flow (see Figure 2).

Peak discharges for both the Sacramento River and Yolo Bypass were also near or above design level in 1986. Figure 3 gives the locations of available gaging station information in the study area. A comparison of design flows and stages versus the peak flows and stages for the February 1986 flood event at these locations is shown in Table 4. In 1986, the Sacramento River approached design flow for the upper reach of the study area and exceeded design flow in the lower reach. Sacramento Bypass and Yolo Bypass flows also approached or exceeded design flows in 1986.

Based on reconnaissance level stage-frequency relationships (using unadjusted historic data), the frequency of the 1986 event for the study area was estimated to fall within the range of 90 to 120 years. Gaging station data for Sacramento River, Sacramento Bypass and Yolo Bypass indicate record high stages for the 1986 flood event (for records generally dating back to the early 1900's). Table 4 indicates that February 1986 peak stages were higher than the design level for both gage locations on the Yolo Bypass and for Sacramento River at Verona. Below Sacramento Weir, stages on the Sacramento River came to within one foot of design stage during February of 1986 (see Figure 4; upper photo courtesy of Brian Yost, USGS, Sacramento, California).

February 1986 water surface elevations were dangerously close to the top of the levee in many parts of the study area. This can be seen in water surface profiles for the Sacramento River, Yolo Bypass and Sacramento Bypass (see Plates 2 through 4). Surveyed high water mark information was compared to surveyed levee crown elevations to determine the freeboard (difference between the high water mark and the levee crown elevations) remaining during the 1986 flood event. Design freeboard for the Sacramento River is 3 feet and for the Yolo Bypass is 6 feet (to account for wave action). In 1986, high water levels were encroaching into the design freeboard in many locations throughout the system. Figure 5 indicates some of the minimum freeboard observations for the 1986 flood event based on the corresponding water surface profiles.

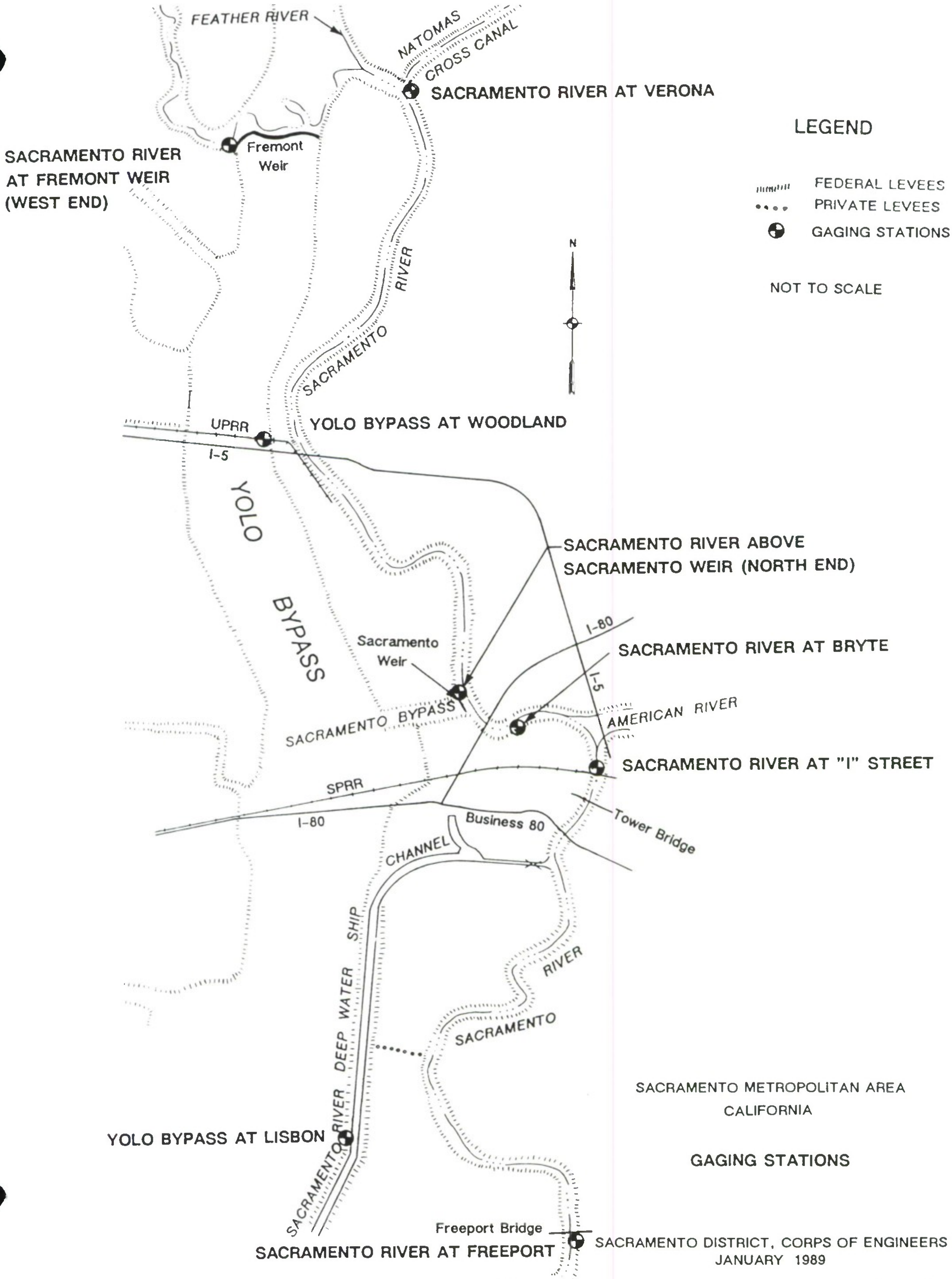


SACRAMENTO RIVER AT TOWER BRIDGE DURING FEBRUARY 1986 FLOOD.

FIGURE 1

SACRAMENTO WEIR AND SACRAMENTO BYPASS NEAR PEAK OF FEBRUARY 1986 FLOOD.

FIGURE 2



SACRAMENTO METROPOLITAN AREA
CALIFORNIA

GAGING STATIONS

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
JANUARY 1989

FIGURE 3

TABLE 4

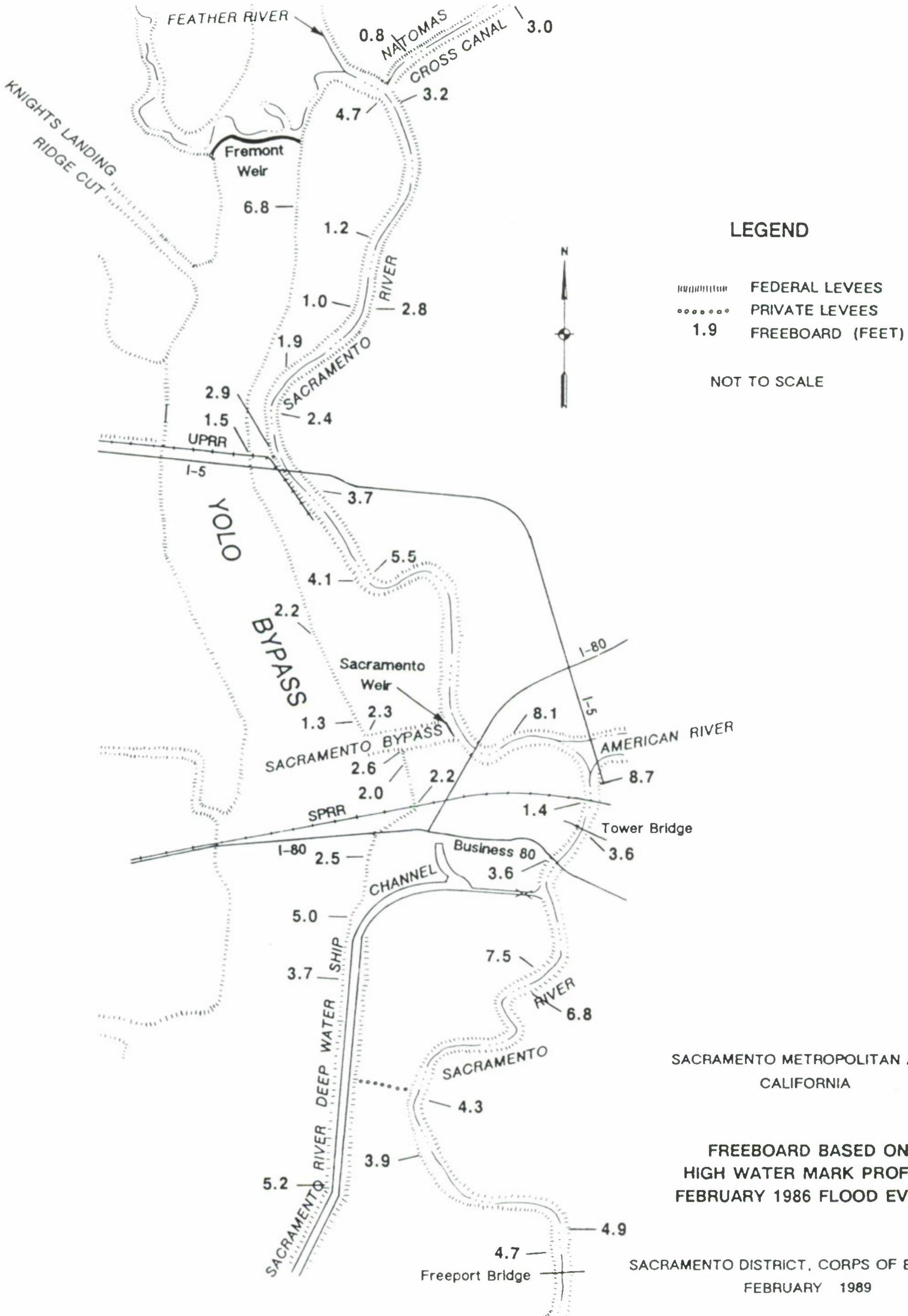
Comparison of Design Flows and Stages
and
Peak Flows and Stages during February 1986 Flood Event

Location	Design Flow (cfs)	February 1986 Peak Flow (cfs)	Design Stage (msl)	February 1986 Peak Stage (msl)
Sacramento River at Verona	107,000	92,900	38.2	39.11
Sacramento River Fremont Weir Spill	343,000	341,000	37.8 1/	38.54 2/
Yolo Bypass near Woodland	377,000	374,000	31.3	31.46
Yolo Bypass near Lisbon	490,000	495,000 to 509,000 (estimated)	23.2	24.88
Sacramento River Sacramento Weir Spill	112,000	127,680	31.5 1/	30.56 2/
Sacramento River at Bryte			31.5	30.65
Sacramento River at I Street			31.1	30.58
Sacramento River at Freeport	110,000	117,000	25.4	25.11

1/ Design stage of Sacramento River opposite location of weir.
2/ Observed water surface elevation on Sacramento River 550 feet upstream of weir.

SACRAMENTO RIVER AT "I" STREET GAGING STATION AND BRIDGE DURING FEBRUARY 1986 FLOOD.

FIGURE 4



SACRAMENTO METROPOLITAN AREA
CALIFORNIA

FREEBOARD BASED ON HIGH WATER MARK PROFILE FEBRUARY 1986 FLOOD EVENT

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
FEBRUARY 1989

FIGURE 5

High flows during the 1986 flood event took its toll on the structural integrity of the levee system. Numerous boils, slips, sloughing, seepage, floodflow erosion and wave erosion often required emergency work by Federal, State and local agencies to minimize or prevent further damage during the flood. Many of the more critical levee embankment damage sites that remained after the floodwaters receded were repaired under the Corps' PL 84-99 program. In the Sacramento District, approximately 108 requests for assistance were received, resulting in 20 separate construction contracts to repair damaged levees within the Sacramento/San Joaquin drainage basin. Figure 6 indicates damaged areas caused by the February 1986 flood event. Some of these areas were involved in emergency flood-fight activities and/or repaired under PL 84-99 or by local entities after the flood.

High water combined with wave action caused extensive erosion damage to the Yolo Bypass levee system. A majority of the damage sites shown for the Yolo Bypass in Figure 6 were related to wave wash damages. Many of these sites required emergency placement of plastic, rock riprap or fill material over the damaged areas during the flood. Some Sacramento River levees also suffered wave erosion damage (see Figure 7).

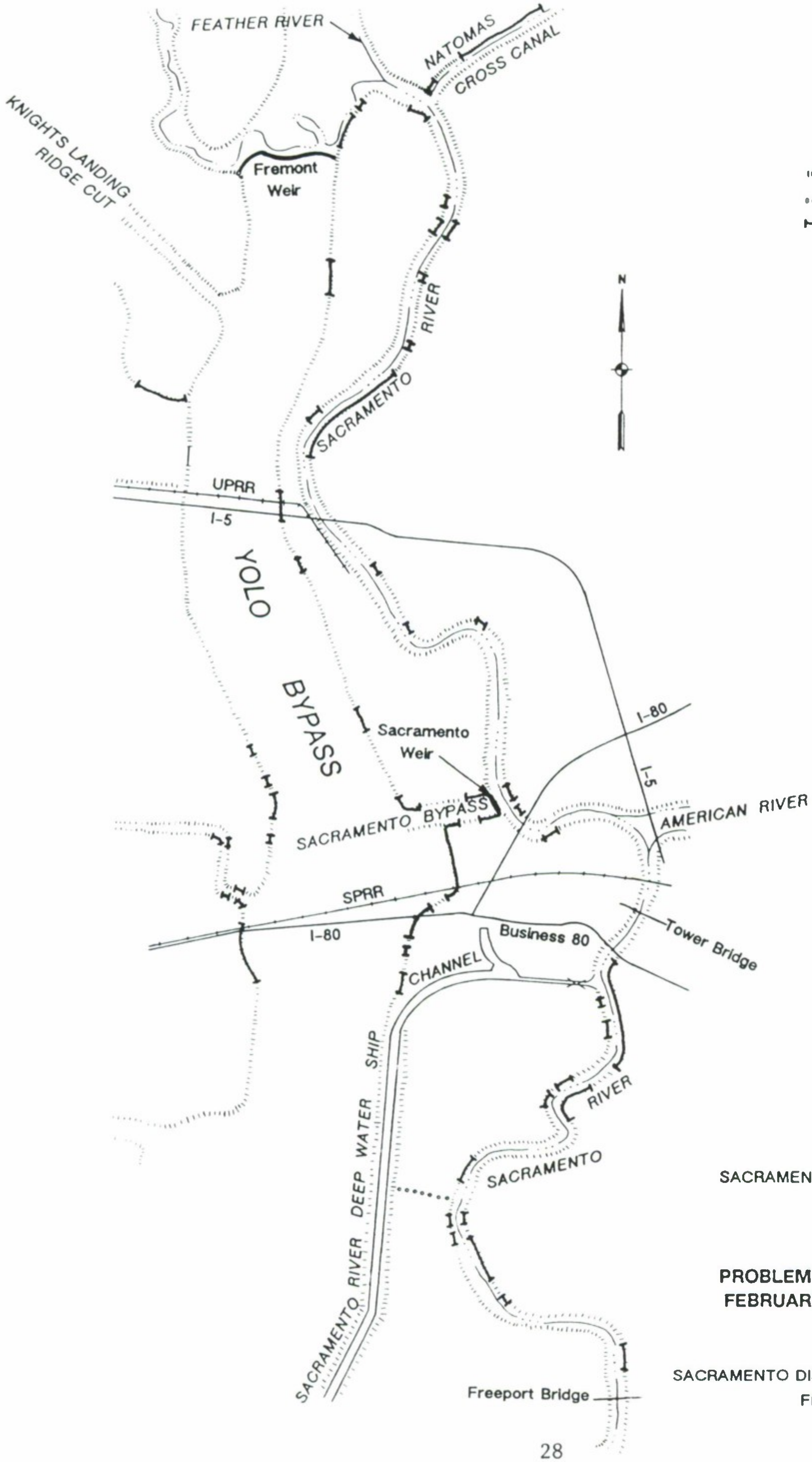
Local observers reported waves up to 6 feet in the Yolo Bypass. Waves reached the levee crown at the intersection of SPRR and the east levee of the Yolo Bypass. Emergency sandbagging was necessary to keep the water from overtopping the levee embankment into the West Sacramento area. Across from Knights Landing Ridge Cut on the Yolo Bypass east levee, waves pushed water over the top of the levee. Wave action almost brought water to the levee crown at a low spot where the UPRR tracks cross the east levee of the Yolo Bypass, and also wetted the east levee crown downstream of I-80. On the east bank of the Sacramento River, emergency sandbagging was needed along openings in the floodwall between "I" Street and the Tower Bridge.

Although Sacramento River levees suffered damage due to wave erosion, the majority of the sites indicated in Figure 6 are associated with the seepage of water through the levee and landside subsidence, slippage or sloughing. From Fremont Weir to the Sacramento Bypass, 24 repair sites were investigated under PL 84-99 for seepage, erosion and sloughing. Further south, wave wash, flow through and under the levees, and landside sloughing were common. Many areas required emergency sandbagging around boils, placement of drain pipe or fill material, and post-flood repair.

In February 1986, the Sacramento Weir and Bypass suffered scour damage associated with high flows and velocities to the concrete apron just downstream of the weir (see Figure 8). Erosion and undercutting damaged the concrete pavement protecting the weir structure as well as the south levee embankment of the Sacramento Bypass. Seepage was also observed along both north and south levees of the bypass while damage from wave erosion occurred where the Sacramento and Yolo Bypass levees intersect.

Future Flood Threat

Although the February 1986 flood was a major flood event, problems that occurred during that flood indicate that similar or larger floods could produce catastrophic damages and loss of life in the future. Wave action in the Yolo Bypass during the flood required emergency sandbagging to prevent wave water from moving over the levee embankment. In addition, emergency



SACRAMENTO METROPOLITAN AREA
CALIFORNIA

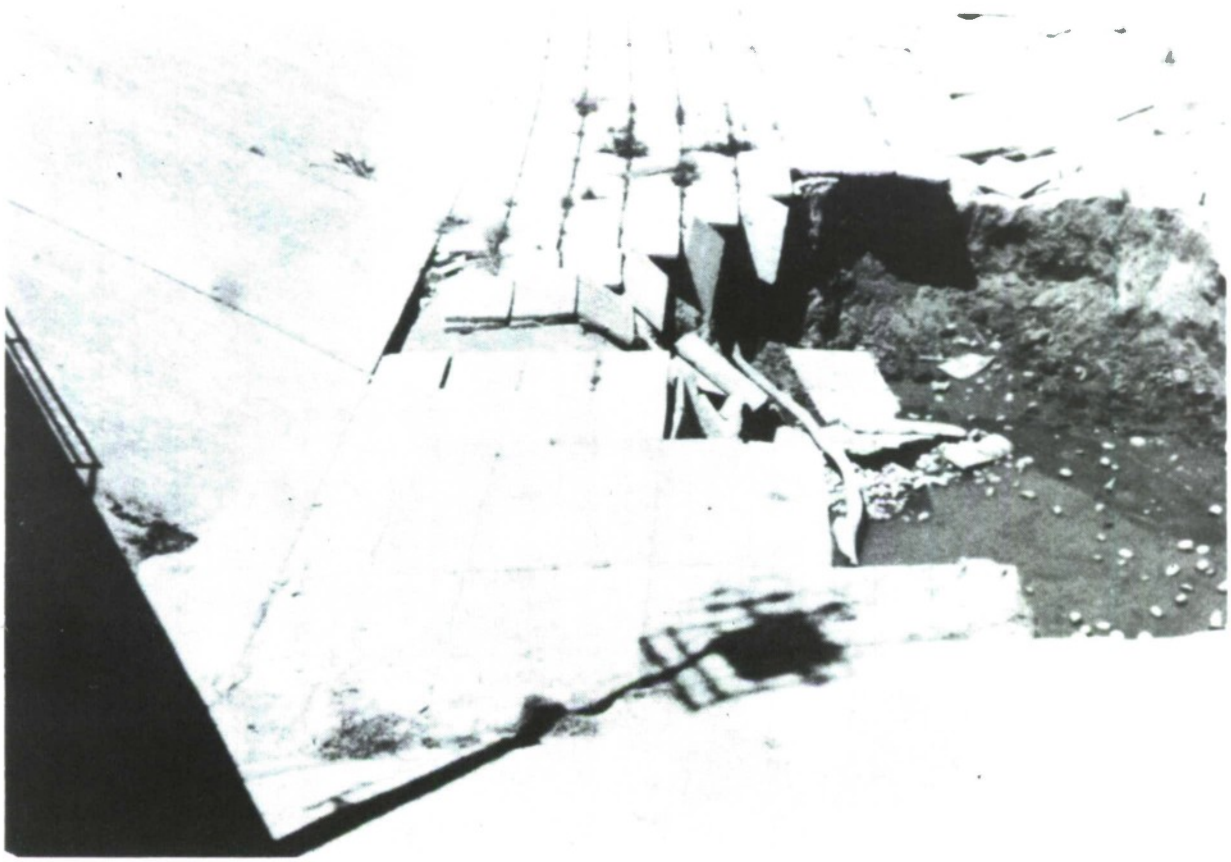
PROBLEM OR DAMAGED AREAS
FEBRUARY 1986 FLOOD EVENT

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
FEBRUARY 1989

FIGURE 6

SACRAMENTO RIVER – WAVE EROSION OF WEST LEVEE EMBANKMENT NEAR FREEPORT (FEBRUARY 1986 FLOOD).

FIGURE 7



DAMAGE TO CONCRETE APRON AT SACRAMENTO WEIR SUSTAINED DURING FEBRUARY 1986 FLOOD.

FIGURE 8

efforts were also required to prevent continued loss of levee embankment material from wave action. Since wind velocities were not severe during that event, future floods of similar magnitude with severe wind conditions could compound problems in the study area. Future floods with peak flows identical to the February event but with longer durations could also compound problems. The longer durations increase the potential for structural failure because levee embankment material is subjected to pressure flow for longer periods. The longer durations also increase the potential for levee embankment erosion due to flow and wave action.

Because sediments are being gradually deposited in the Yolo Bypass and overbank areas of the Sutter Bypass during major flood events, the flow conveyance capacities of these bypasses are being reduced. With reduced capacity over time, future flood events similar to the February 1986 flood would result in higher peak flood stages in the Yolo Bypass adjacent to urban areas.

Land use changes are resulting in increased runoff into the flood control system. Levee improvements and flood control facilities constructed on Arcade Creek, Dry Creek and the Natomas East Main Drainage Canal since the 1986 flood would probably increase the peak flow in the study area by 1,000 to 2,000 cfs if the February 1986 storm were to occur again. Other channel and levee improvements are expected in the study area and upstream of the study area in the future. Future development will also increase runoff into the flood control system. Although the increased runoff due to projected land use changes might be considered small when compared to the total flow in the system, such runoff increases the potential for problems during major floods.

Although additional flood control storage space on the American River in conjunction with levee strengthening and raising in other parts of the study area would achieve higher levels of flood protection for the Sacramento and West Sacramento urban areas, caution should be expressed with regard to the future flood threat. Historically, high flood stages in the study area have resulted primarily from various combinations of flows emanating from the upper Sacramento, the Feather and the American Rivers. Additional flood control storage space on the American River can have a significant impact in reducing the flood threat when the American River watershed experiences significant runoff. For those floods in which the major runoff is from the upper Sacramento and the Feather Rivers additional flood control storage space on the American River may not have any impact on reducing the future flood threat. Levee raising in the study area is necessary even with a dry dam or multi-purpose facility at or near the Auburn Dam site to accommodate those conditions where the upper Sacramento and Feather River are experiencing major floods.

Raising levees to hold additional floodwaters within the study area can create additional problems. Floods greater than anything we design for can always occur and with high intensity development landward of the levees, levee failure would result in catastrophic damages and loss of life. In addition, the design of higher levees in this area is based on the existing channel and levee system upstream of the study area. If significant modifications are made to that system in an effort to confine more of the floodwaters within existing or new flood control channels, increased volumes of floodwater could reach the study area in the future for flood events with recurrence intervals

of 100 years or greater. This condition would have to be considered and constantly evaluated when using designs that require higher levees. Because of potential development and land use changes expected local land use planners should be aware of future conditions and should probably begin efforts to increase flood control storage space on the upper Sacramento and Feather Rivers.

RECREATION

The Sacramento River supports a variety of recreational activities including fishing, boating, water skiing, hiking and picnicking. Along both the Yolo and Sacramento Bypasses, recreational activities are limited to fishing for warm water resident fish. Although demand for recreational facilities is expected to increase in the future as local and regional populations increase, recreational opportunities in the study area are limited due to seasonal flooding of the bypasses and limited public access.

CHAPTER IV - TECHNICAL STUDIES

This chapter provides a detailed discussion of the technical studies of the investigation. Data on levee crown surveys and high water marks of the February 1986 flood are provided. Also, hydrologic studies addressing the derivation of stage-frequency curves and the analysis of historic flood data are included. The hydraulic studies include a detailed flow and sediment analysis of the conveyance facilities in the study area, including the Sacramento Weir, Fremont Weir, Sutter Bypass, Yolo Bypass, and the Sacramento River Deep Water Ship Channel. This chapter also covers economic studies, including the analysis of historic flood data and the determination of estimated annual flood damages.

FIELD DATA

Levee Crown Surveys

Levee crown surveys were conducted during 1987 and 1988 by DWR personnel in cooperation with the Corps. Also, additional levee crown data were also provided by Reclamation District 1000, Reclamation District 900, and the city of Sacramento. All levee crown elevations are referenced to mean sea level datum (see Plates 2 through 4).

Levee crown elevations are available for the following levee reaches:

- Natomas Cross Canal
  North and south levees

- Sacramento River
  East levee from Sutter Bypass to Freeport
  West levee from Fremont Weir to Freeport

- Sacramento Bypass
  North and south levees (excluding training levee on south side)

- Cross levee (private levee at southern boundary of West Sacramento) from the Sacramento River Flood Control Project levee on the Sacramento River to the Sacramento River Flood Control Project levee on the Yolo Bypass

- Yolo Bypass
  East levee from Fremont Weir to cross levee
  West levee from Fremont Weir to Putah Creek

- Ship Channel
  West levee from Yolo Bypass levee to Lisbon

- Putah Creek
  North levee (from mouth upstream 1 mile)

- Willow Slough
  North and south levees (from mouth upstream 1.5 miles)

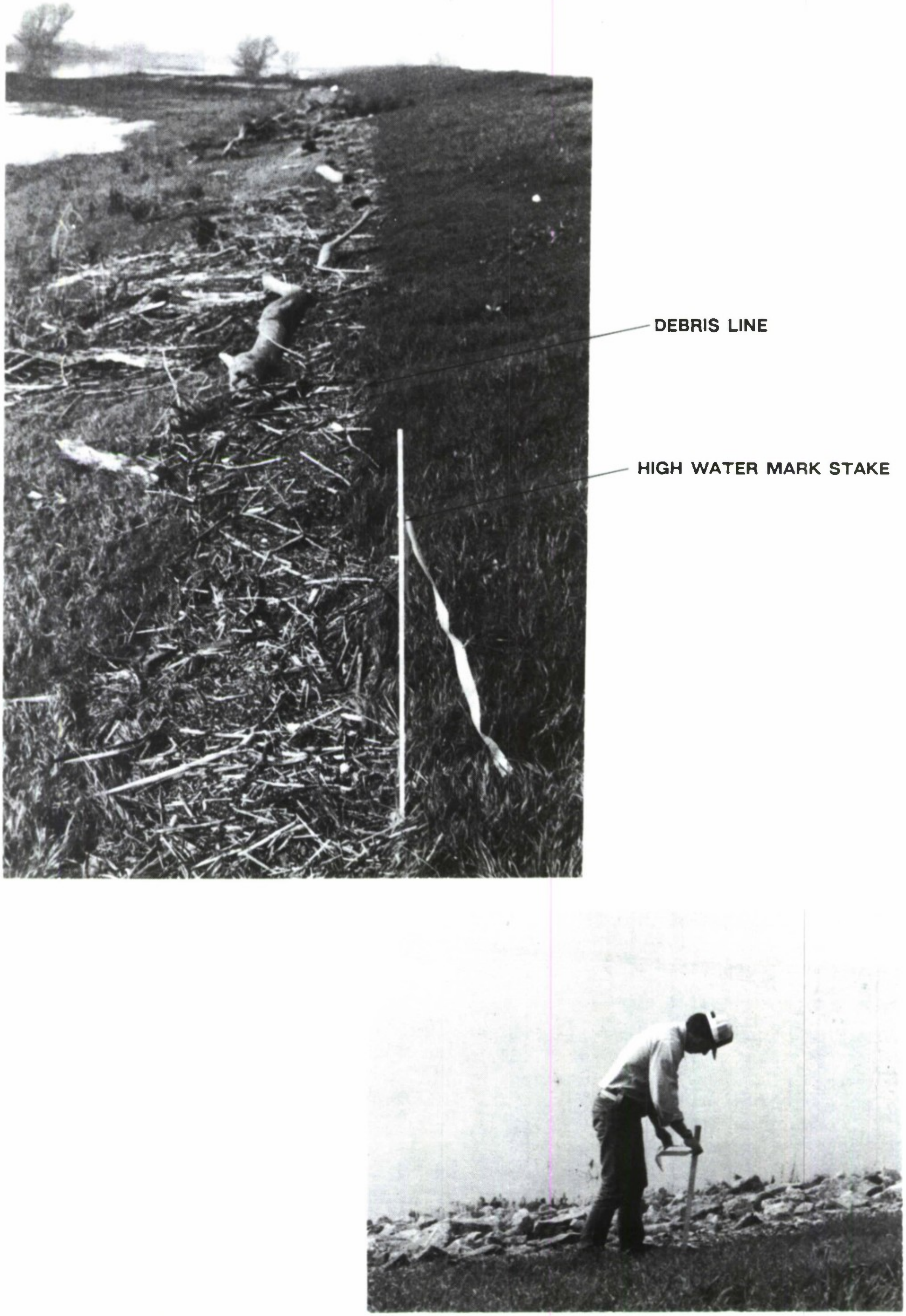
Levee crown elevations were obtained at low points, gradient changes, road and bridge locations, and approximately every 500 feet.

Since the February 1986 flood event, various reaches of the Sacramento River Flood Control Project levee system have been modified. The floodwall on the east side of the Sacramento River between "I" Street and Capitol Mall (Tower Bridge) has been reconstructed and raised. In addition, floodgates have been installed at openings in the floodwall to provide access to the dock area. Openings are in the top of the floodwall and are generally about 1 to 4 feet deep and 5 to 12 feet wide. The profile plot of this reach shows elevations of floodwall and floodgates. Since the city of Sacramento has plans to install the gates during major flood events, they are considered an integral part of the floodwall system in this study. The south levee of the Natomas Cross Canal and the east levee of the Yolo Bypass between I-80 and the Ship Channel have also been modified, and those modifications are reflected in the levee crown profiles.

Vertical and horizontal scales used in the levee crown profile plots were selected to clearly define the localized depressed areas of the levee embankment crown. The Sacramento River profile (Plate 2) indicates that about 500 feet of the west levee crown just downstream of the "I" Street bridge is depressed. If this levee reach was reconstructed and raised, a significant increase in levee embankment freeboard would be achieved on the Sacramento River side of West Sacramento. (Design freeboard is 3 feet.) The Yolo Bypass profile (Plate 3) indicates that the Union Pacific Railroad (near I-5) cuts through both the east and west levee embankment crowns. Whether floodgates (similar to floodgates constructed by the city of Sacramento on Arcade and Dry Creeks) could be constructed and operated at this location to increase freeboard will be considered in the evaluation of potential flood control alternatives. On the Natomas Cross Canal, the south levee embankment crown is depressed at the Highway 99 crossing, whereas on the north levee, between 300 and 700 feet of levee crown is depressed adjacent to the pumping facilities for Reclamation District 1001. Similar localized depressed areas exist on the Sacramento Bypass (Plate 4). An inspection of the levee crown profiles indicates that raising these levee embankments at these localized depressed areas can significantly increase the levee freeboard within specific channel reaches.

February 1986 High Water Mark Profiles

After the February 1986 flood event, personnel from the Corps staked high water marks (see Figure 9) along the levee embankments of the Sacramento Bypass, the east levee of the Yolo Bypass from Fremont Weir to the Ship Channel, and the west levee (on the Yolo Bypass side) of the Ship Channel downstream to Cache Slough. The high water marks were later surveyed and elevations were obtained for the levee embankment crown immediately adjacent to those locations. This levee crown data also supported and complemented the levee crown surveys by DWR. On the Sacramento River between Fremont Weir and Freeport, high water mark elevations were obtained from the report, "Profile of Sacramento River, Freeport to Verona, California, Flood of February 1986," U.S. Geological Survey, 1988. In addition, gaged data from Table 5 were also used for these areas.



HIGH WATER MARK STAKING OF FEBRUARY 1986 FLOOD
(EAST LEVEE OF YOLO BYPASS NEAR INTERSTATE 80).

FIGURE 9

TABLE 5

Peak Flows and Stages
February 1986 Flood Event

Location	Time (date/hours)	Elevation (msl)	Flow (cfs)
Sacramento River at Verona	Feb 20 0215	39.11 1/	92,900
Sacramento River Fremont Weir Spill	Feb 20 0300	38.54 2/	341,000
Yolo Bypass near Woodland	Feb 20 0745	31.46	374,000
Yolo Bypass near Lisbon	Feb 20 1330	24.88	495,000 to 509,000 (estimated)
Sacramento River Sacramento Weir Spill	Feb 20 0115	30.56 3/	127,680
Sacramento River at Bryte	Feb 20 0015	30.65	
Sacramento River at I Street		30.58	
Sacramento River at Freeport	Feb 19 1900	25.11	117,000
American River at Fair Oaks	Feb 19 1315	99.49	134,000
American River at Sacramento (H Street Bridge)	Feb 19 0215	40.32	

1/ Elevation recorded at mouth of Natomas Cross Canal.
2/ Elevation recorded 550 feet upstream of west end of Fremont Weir on Sacramento River.
3/ Elevation recorded 550 feet upstream of Sacramento Weir on Sacramento River.

Other high water mark observations were obtained from various State and local entities, but those observations were not surveyed. Instead, the observations were referenced to their locations on bridge or weir structures, and with respect to top of levee embankment. High water mark elevations at structures could be reasonably determined because of available design and construction elevations for such structures. Minimum freeboard data for the February 1986 flood are presented in Table 6.

Also, other types of information provided insight on peak water surface elevations. During the February 1986 flood event, sandbags were placed on top of the east levee embankment of the Yolo Bypass immediately upstream of the SPRR to stop the movement of floodwaters over the levee crown. Sandbags were also needed at one of the openings in the floodwall on the east side of the Sacramento River between "I" Street and Capitol Mall (Tower Bridge). On the east levee of the Yolo Bypass just downstream of I-80, wave action put water on top of the levee crown. (Since the February 1986 flood event, levee and floodwall improvements have been made at these critical locations.)

Based on the above information, high water mark profiles of the February 1986 flood event were developed for the Sacramento River, Yolo Bypass, and Sacramento Bypass as shown in Plates 2 through 4. These profile plots also indicate the levee crown elevations. These profiles represent physical conditions as of September 1988 and include the levee embankment and floodwall improvements discussed in the section "Levee Crown Surveys."

The high water mark profiles indicate the streamflow data from gages operated by the Corps, USGS and DWR. The gaged data (because of the types of devices used such as pressure manometers, stilling wells, etc.) generally represent a water surface elevation that would be consistent with a static water surface or a static water surface plus wind setup. The gage devices essentially dampen out any wave action that might be occurring on the water surface.

As shown in Figure 9, high water mark stakes were generally placed where a debris line was evident on the levee embankment slopes. In river reaches where wave action is not significant, the debris line elevations are probably similar to water surface elevations observed at the gaging stations operated by the Corps, USGS and DWR. In the Yolo Bypass, wave action can be significant and can create a debris line that is significantly different from the observed gaging station elevations. The high water mark profile of the Yolo Bypass, as surveyed by the Corps, indicates that the gaged water surface elevations are within 0.2 to 0.3 foot of the high water mark profile elevations. Because the gaged data is relatively close to the debris line data, the high water mark profile for the Yolo Bypass is assumed to represent the static water surface elevation plus wind setup.

HYDROLOGY

Stage-Frequency Analysis

Stage-frequency relationships were adopted for the study area because most of the gaged data (stage and flow) are affected either by backwater conditions, tidal conditions or operation of the gates at the Sacramento Weir. Backwater conditions or high flood stages in the Yolo Bypass at the mouth of the

TABLE 6

Minimum Freeboard 1/
for
February 1986 High Water Mark Profile

Location	Freeboard (feet)
Natomas Cross Canal	
North levee (at pumphouse about 1 mile upstream of mouth)	0.8
North levee (about 2 miles upstream of mouth)	2.7
South levee (at Highway 99)	2.3
South levee (about 1 mile downstream of Highway 99)	3.0
Sacramento River	
West levee (between Fremont Weir and Interstate 5)	1.0
West levee (near "I" Street)	1.4
West levee (near Business 80)	3.6
East levee (near Interstate 5)	2.4
East levee (near Tower Bridge)	3.6
Yolo Bypass	
East levee (upstream of Union Pacific Railroad)	4.8
East levee (at Union Pacific Railroad)	1.5
East levee (just upstream of Sacramento Bypass)	1.3
East levee (just downstream of Sacramento Bypass)	2.0
Sacramento River Deep Water Ship Channel	
West levee (just downstream of the intersection of the Yolo Bypass and ship channel levee)	3.7
Sacramento Bypass	
North levee (near Yolo Bypass levee)	2.3
South levee (near Yolo Bypass levee)	2.6

1/ Minimum freeboard based on levee crown elevations presented in Plates 1 through 3. Levee crown elevations represent physical conditions as of September 1988.

Sacramento Bypass affect the flow rate of the Sacramento Weir for a specified water surface elevation at the weir. Tidal conditions, if significant, impact the stages of the Sacramento River at Freeport. (Prior studies indicate that the impacts are much more significant at lower flows and become insignificant during infrequent flood events.) Also, the operation of the Sacramento Weir can influence flood stages (and flow rates) within the entire study area.

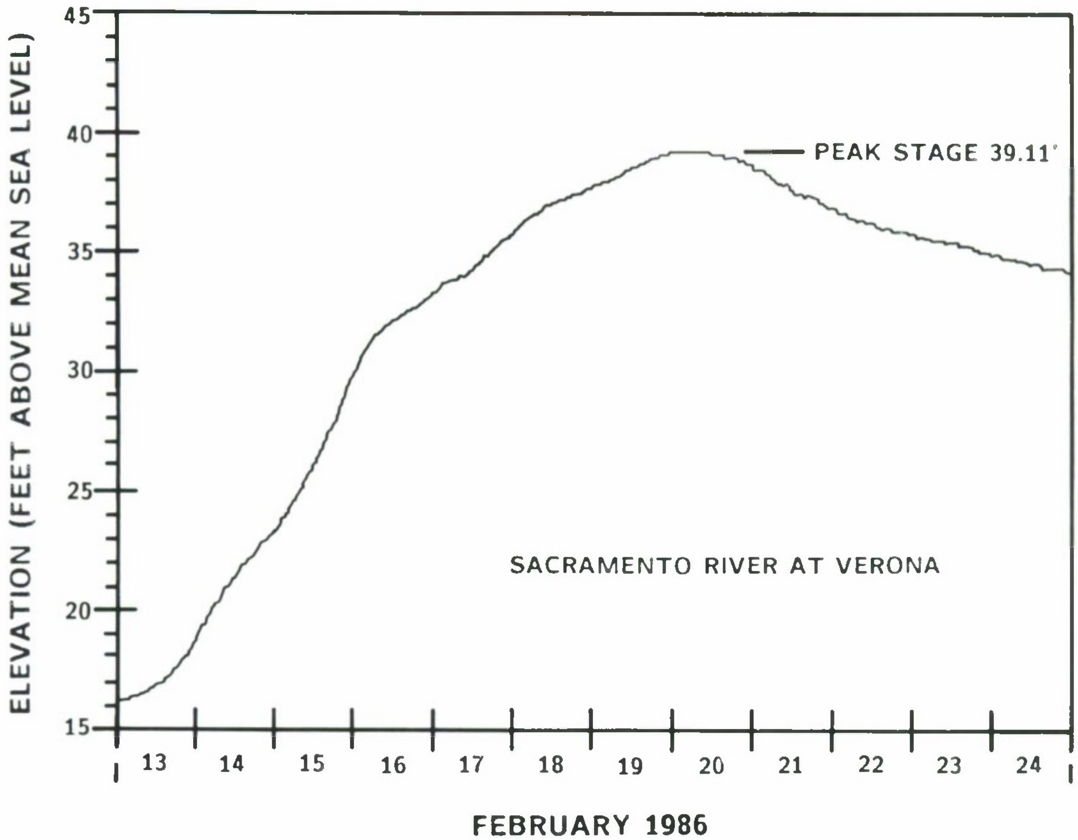
As shown by the stage hydrographs for the February 1986 flood event (see Figure 10), after the opening of the gates on the Sacramento Weir commenced (February 17 at 0128 hours), there was a noticeable drop in the floodwater elevation near the weir and at Sacramento River at Bryte, at "I" Street and at Freeport. In addition, there was also a perceptible change in the slope of the stage hydrograph of the Sacramento River at Verona. (Changes in slope could not be detected from an examination of the stage hydrographs of the Yolo Bypass at Woodland and at Lisbon.)

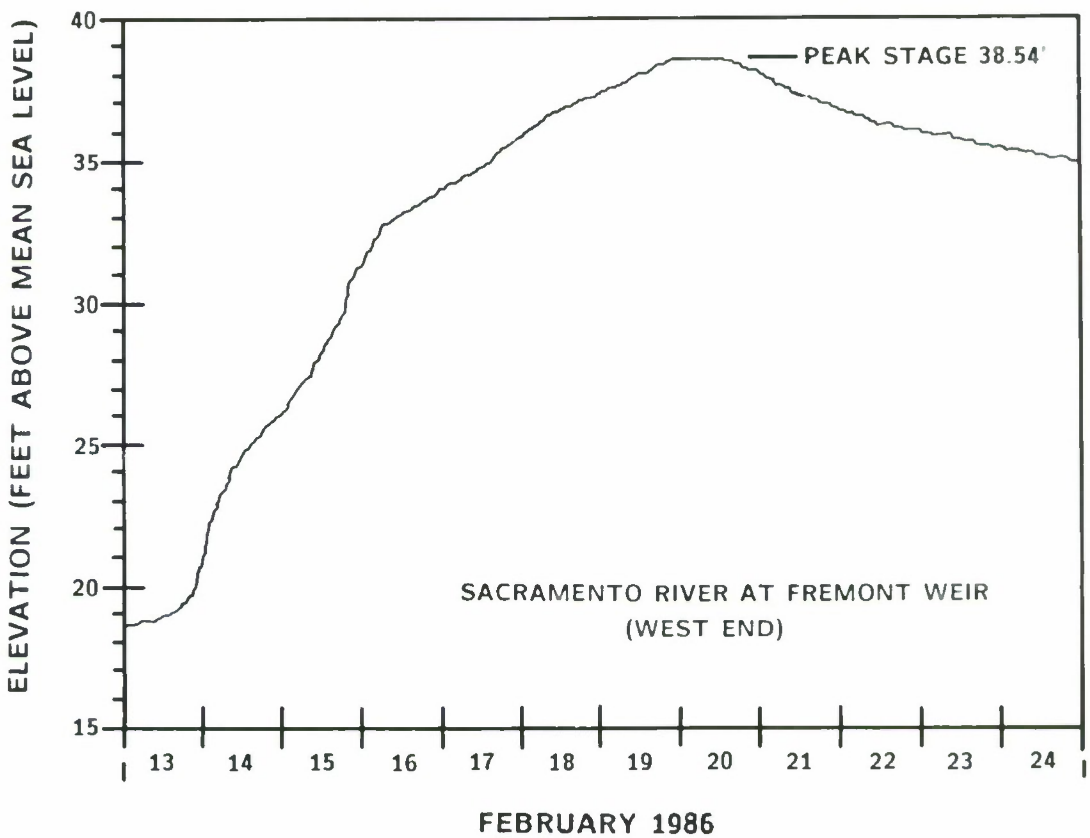
As a result, reconnaissance level stage-frequency relationships were developed (rather than discharge-frequency relationships) at the following locations in the study area:

- Sacramento River at Fremont Weir (west end)
- Sacramento River at Verona
- Sacramento River at "I" Street Bridge
- Yolo Bypass near Woodland
- Yolo Bypass near Lisbon

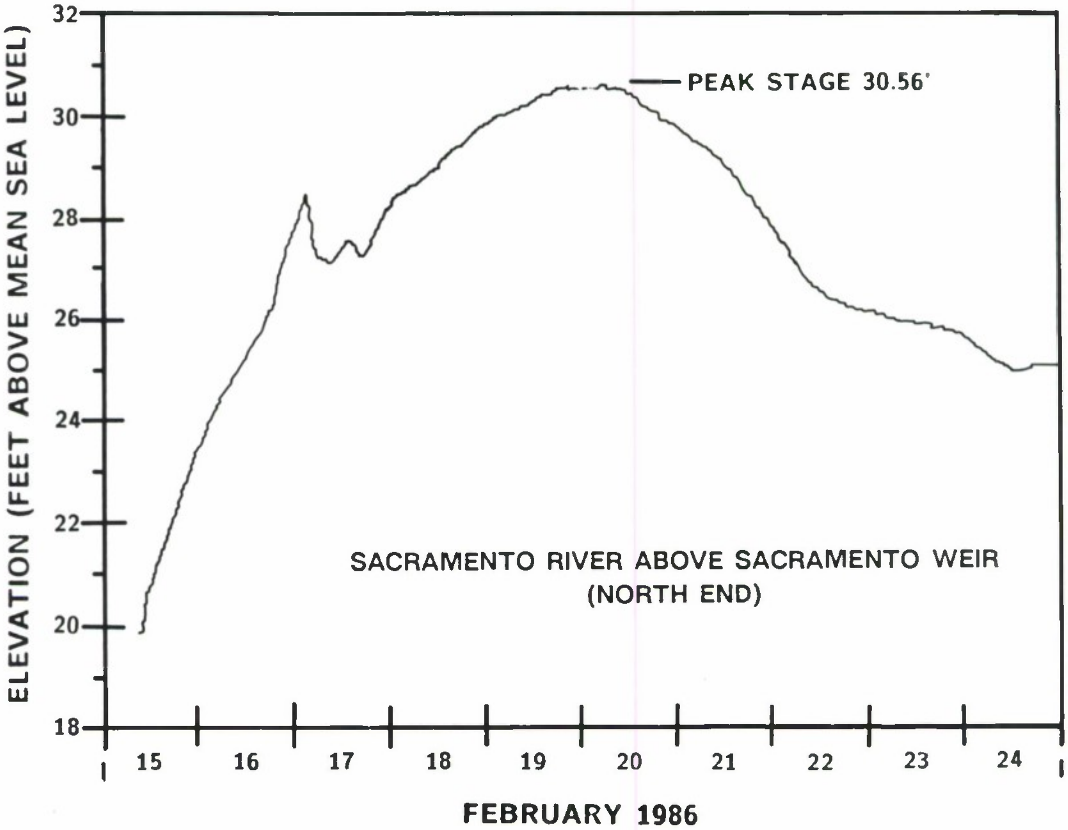
Stage-frequency curves were developed by plotting historic annual peak stage data at each of the above locations (see Figures 11 through 15). The observed maximum annual stages used in the development of these historic stage-frequency curves are tabulated in Table 7. Initially, different lengths of record were used in the evaluation in an effort to determine the sensitivity of the stage-frequency curves to record length and time period. The results indicated that for infrequent flood events (50-year, 100-year and 200-year) there were no significant differences in the stages whether the record used was for the period of record 1971 through 1986, 1967 through 1986, 1943 through 1986, or the entire record (not shown in Table 7).

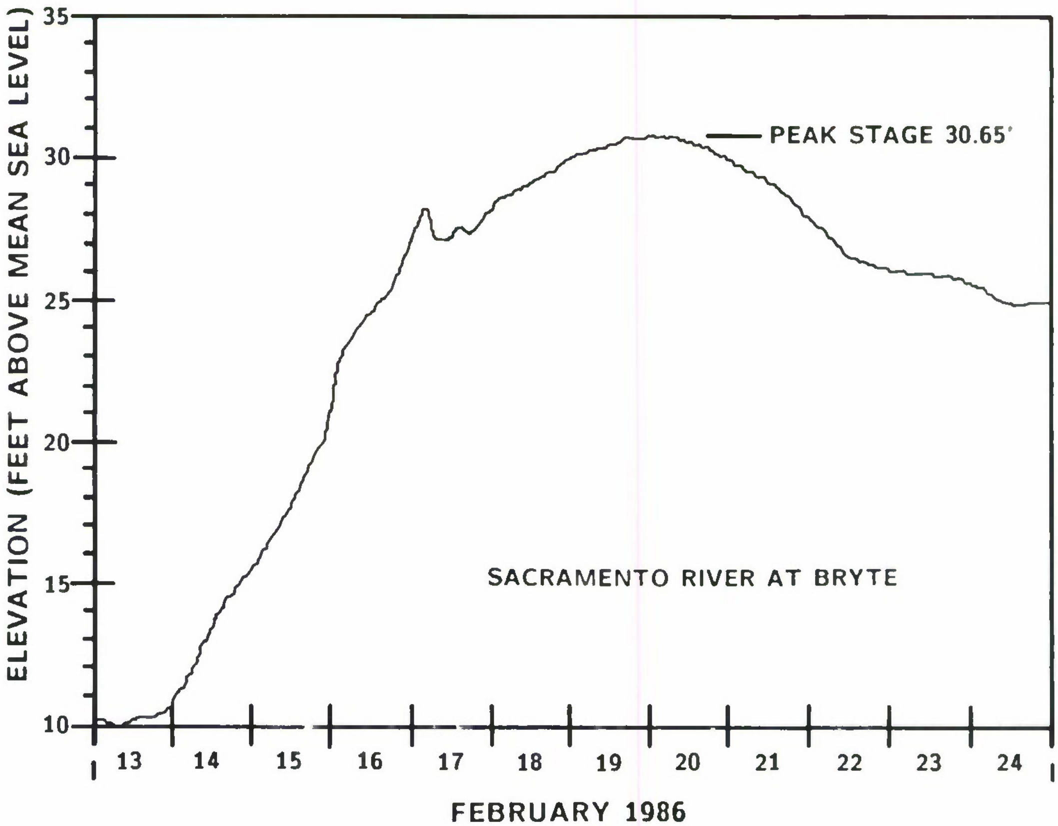
One reason for using the most recent records of stage data in the analysis was to use historic stage data that would generally represent the existing physical flood control system. For example, if there were no significant land use changes in the system during this latest period of record, a repeat of the 1971 rainfall event would produce flood stages in 1988 nearly the same as those recorded in 1971. The shorter, most recent period of record generally coincided with the completion of major flood control facilities in the watershed area. Some of these facilities included Shasta Dam and Reservoir (1943), Folsom Dam and Reservoir (1956), Oroville Dam and Reservoir (1967),and New Bullards Bar Dam and Reservoir (1971). In addition, many other physical changes have occurred in the system, including levee embankment modifications





STAGE HYDROGRAPHS-FEBRUARY 1986 FLOOD EVENT





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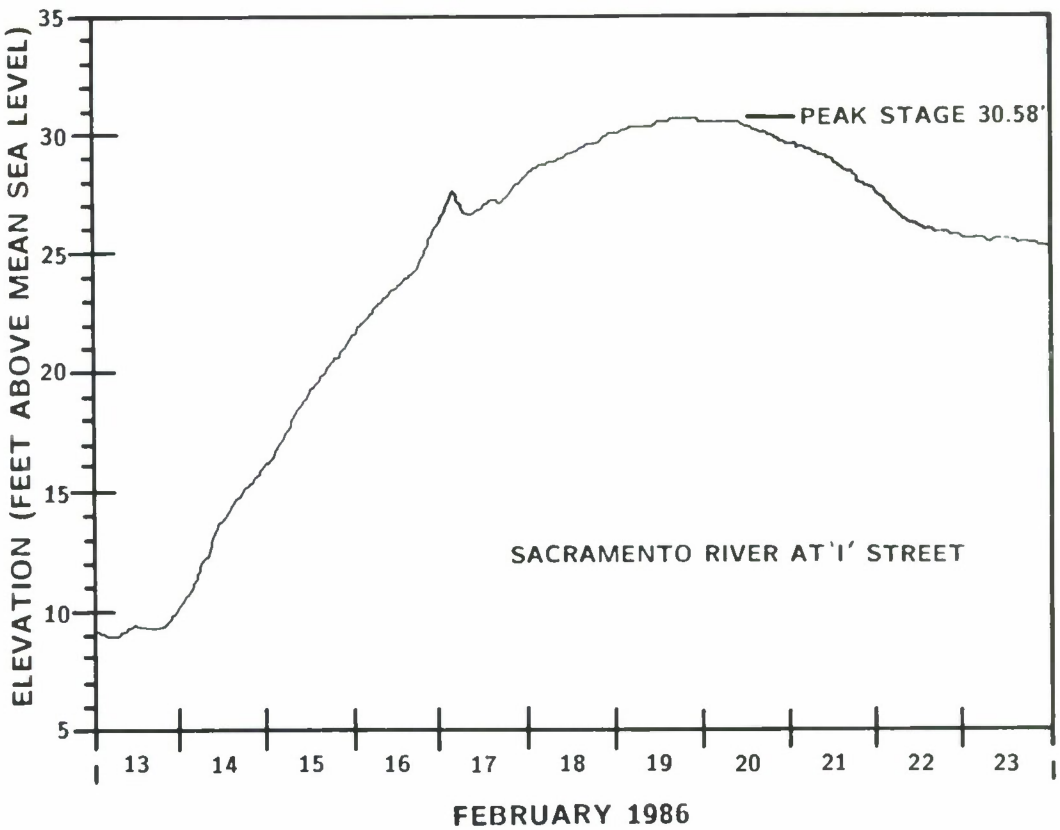

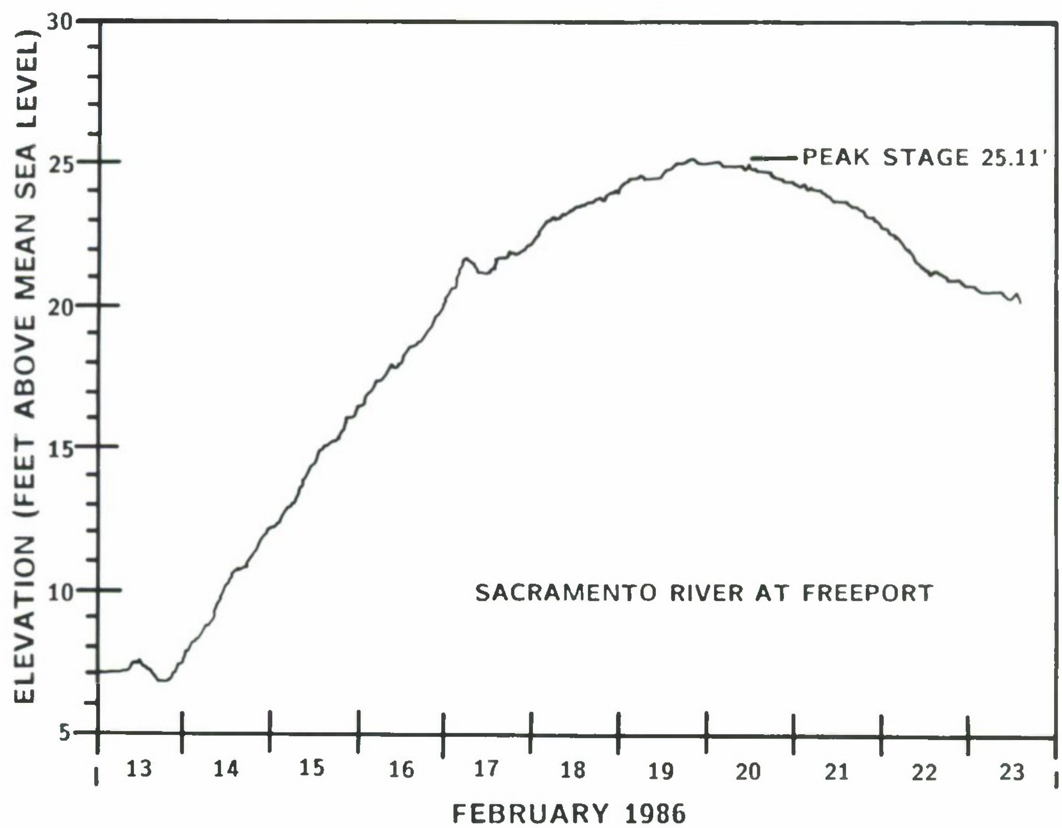

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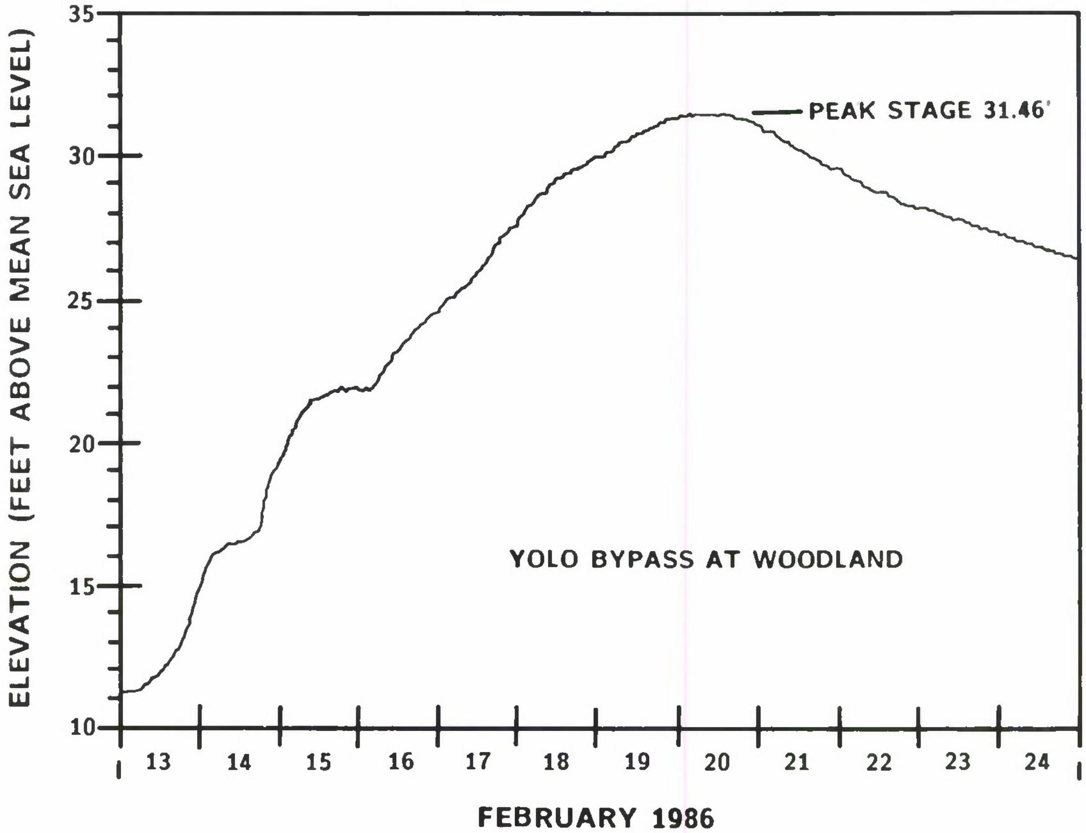
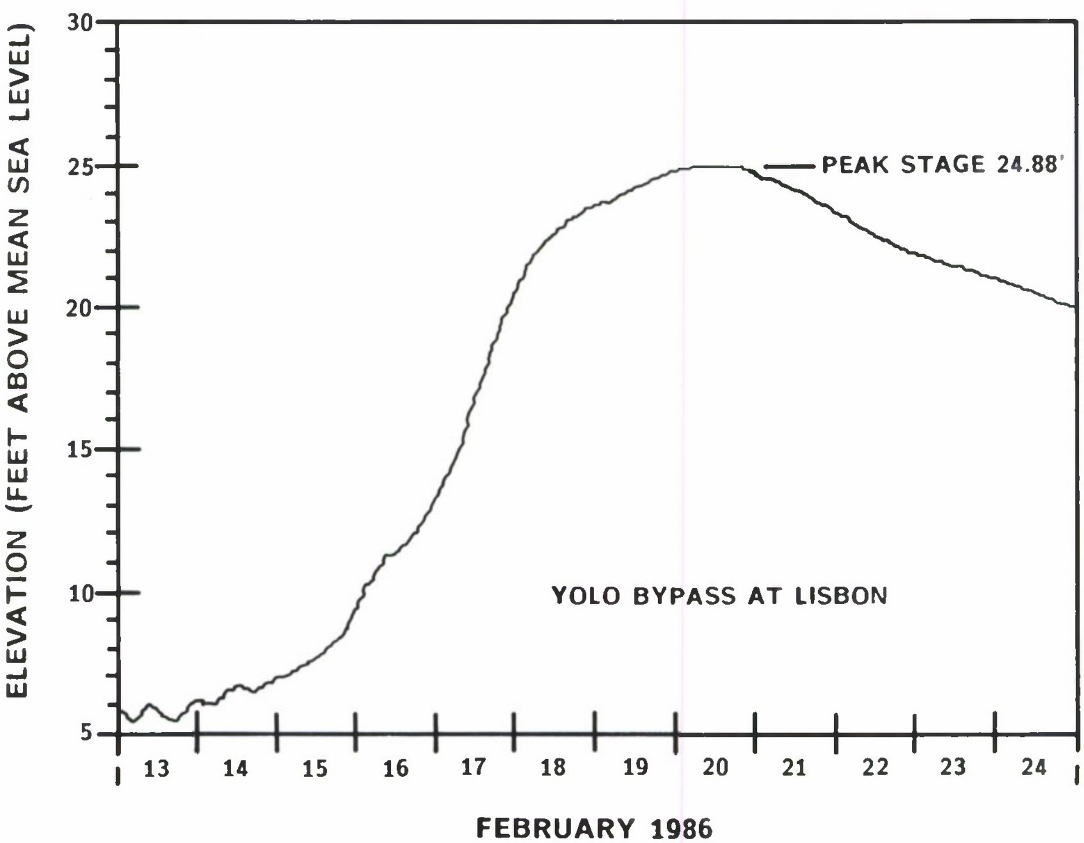
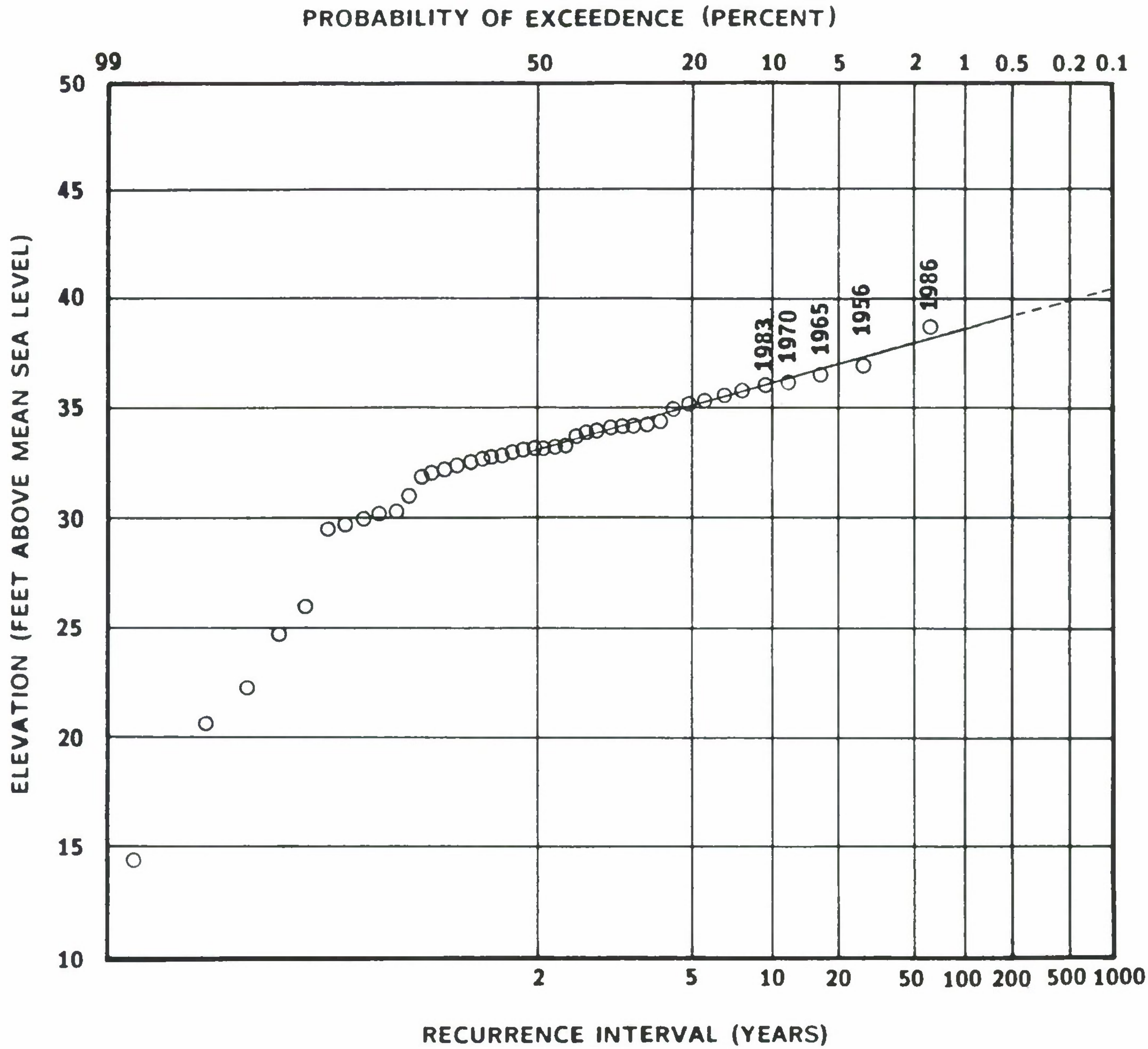




STAGE HYDROGRAPHS-FEBRUARY 1986 FLOOD EVENT



SACRAMENTO METROPOLITAN AREA
CALIFORNIA

STAGE-FREQUENCY RELATIONSHIP

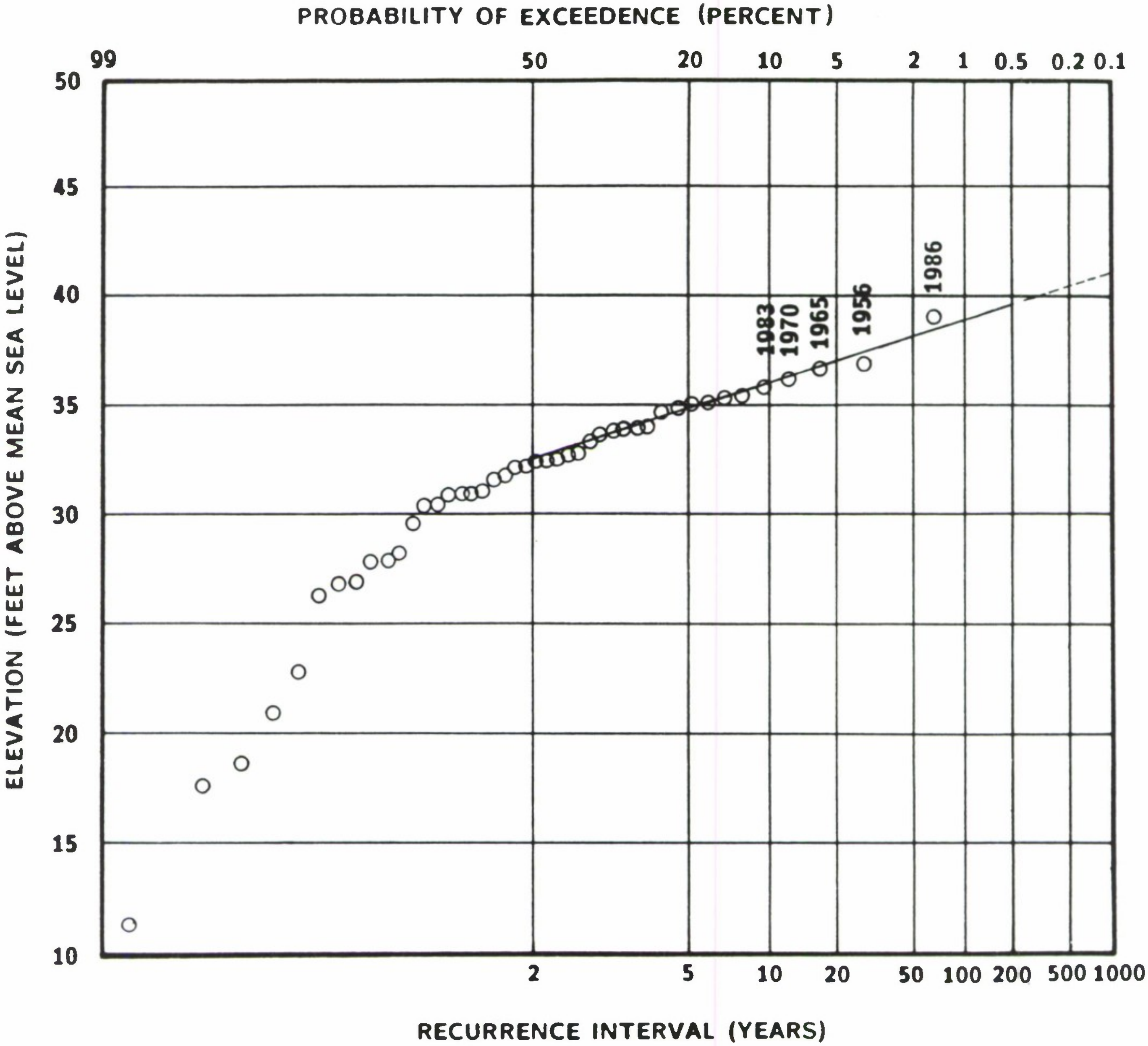
SACRAMENTO RIVER AT

FREMONT WEIR/WEST END

SACRAMENTO DISTRICT, CORPS OF ENGINEERS

June 1988

FIGURE 11



SACRAMENTO METROPOLITAN AREA
CALIFORNIA

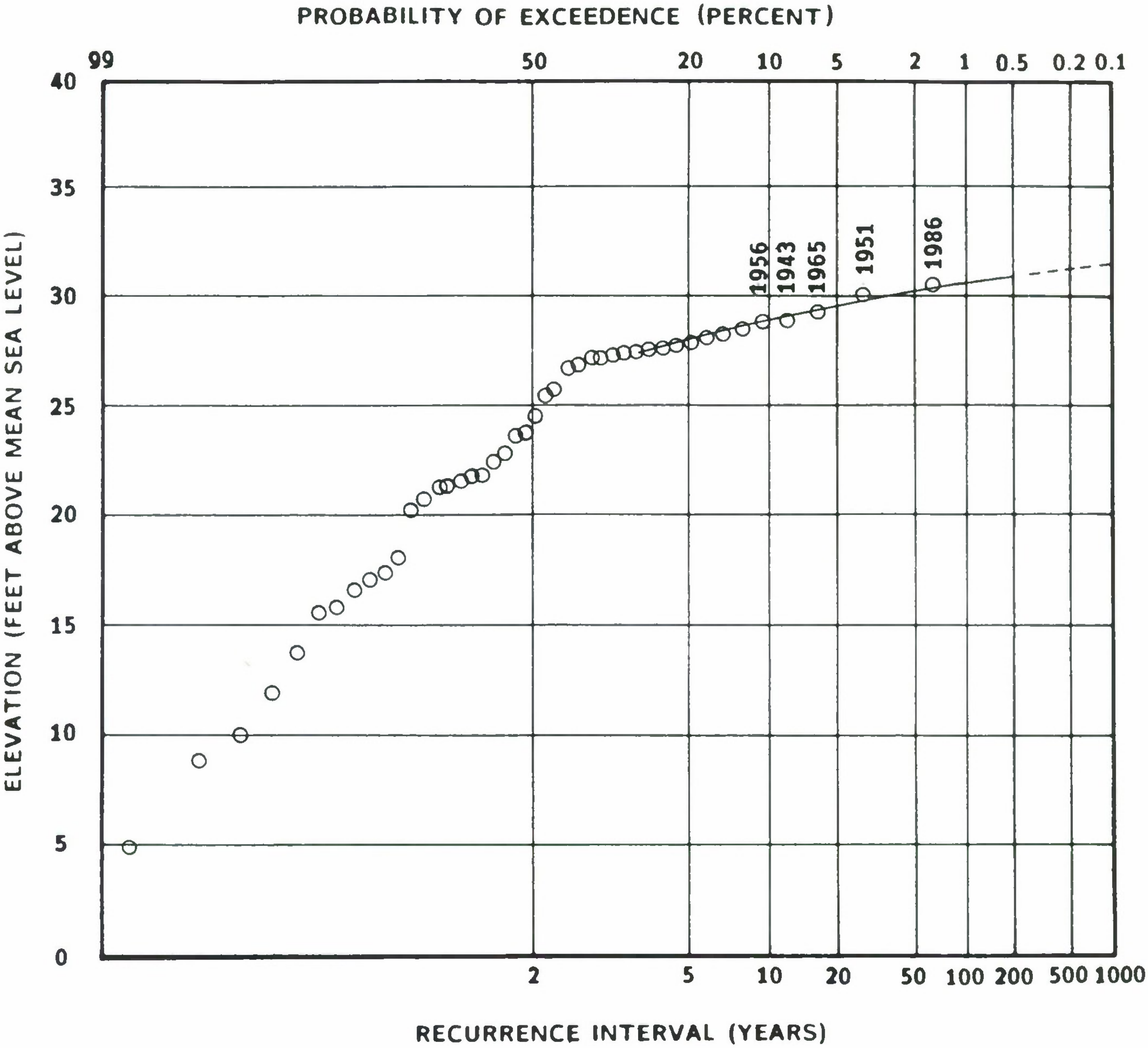
STAGE-FREQUENCY RELATIONSHIP

SACRAMENTO RIVER AT VERONA

SACRAMENTO DISTRICT, CORPS OF ENGINEERS

June 1988

FIGURE 12



SACRAMENTO METROPOLITAN AREA
CALIFORNIA

STAGE-FREQUENCY RELATIONSHIP

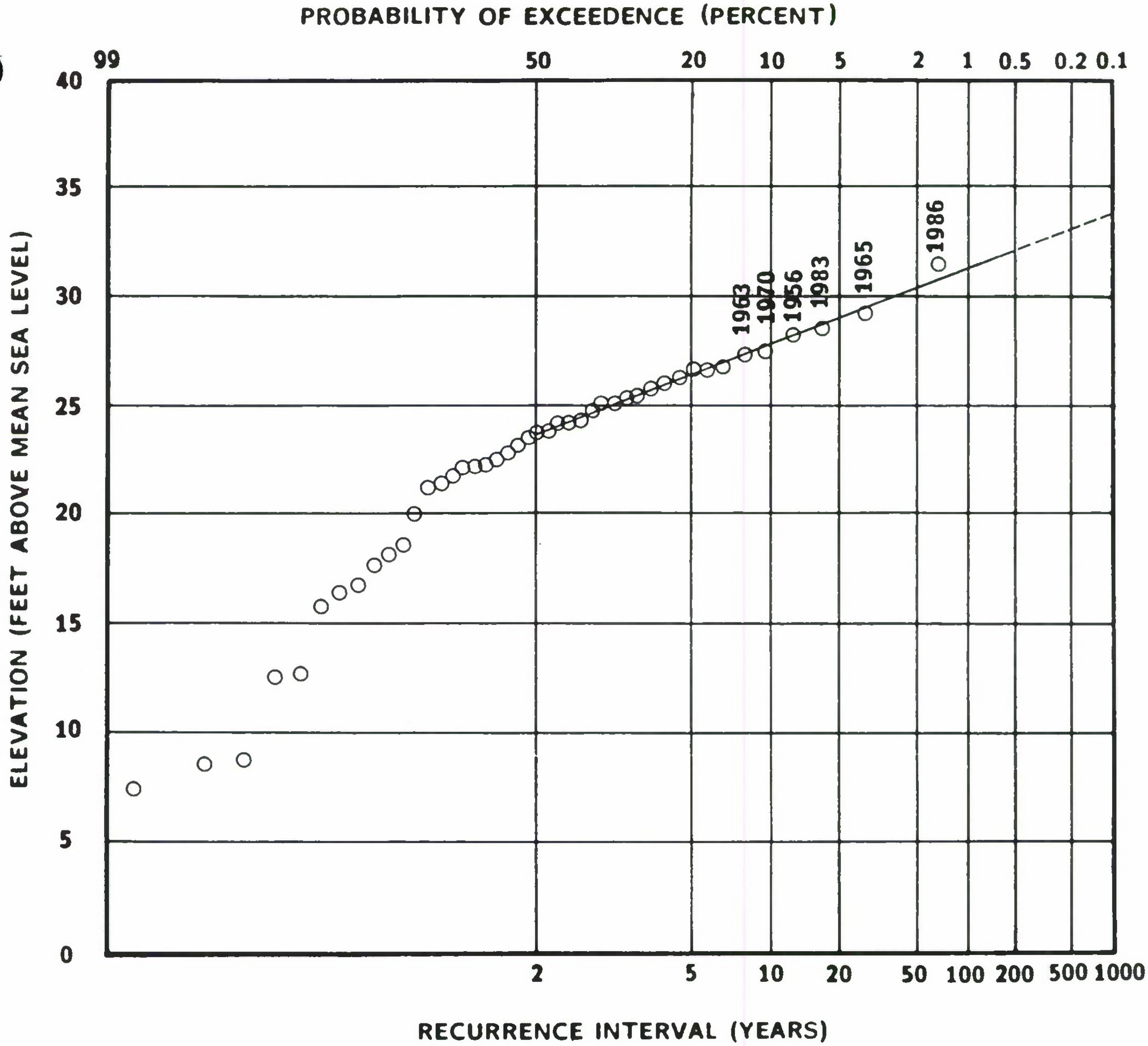
SACRAMENTO RIVER

AT I - STREET BRIDGE

SACRAMENTO DISTRICT, CORPS OF ENGINEERS

June 1988

FIGURE 13



SACRAMENTO METROPOLITAN AREA
CALIFORNIA

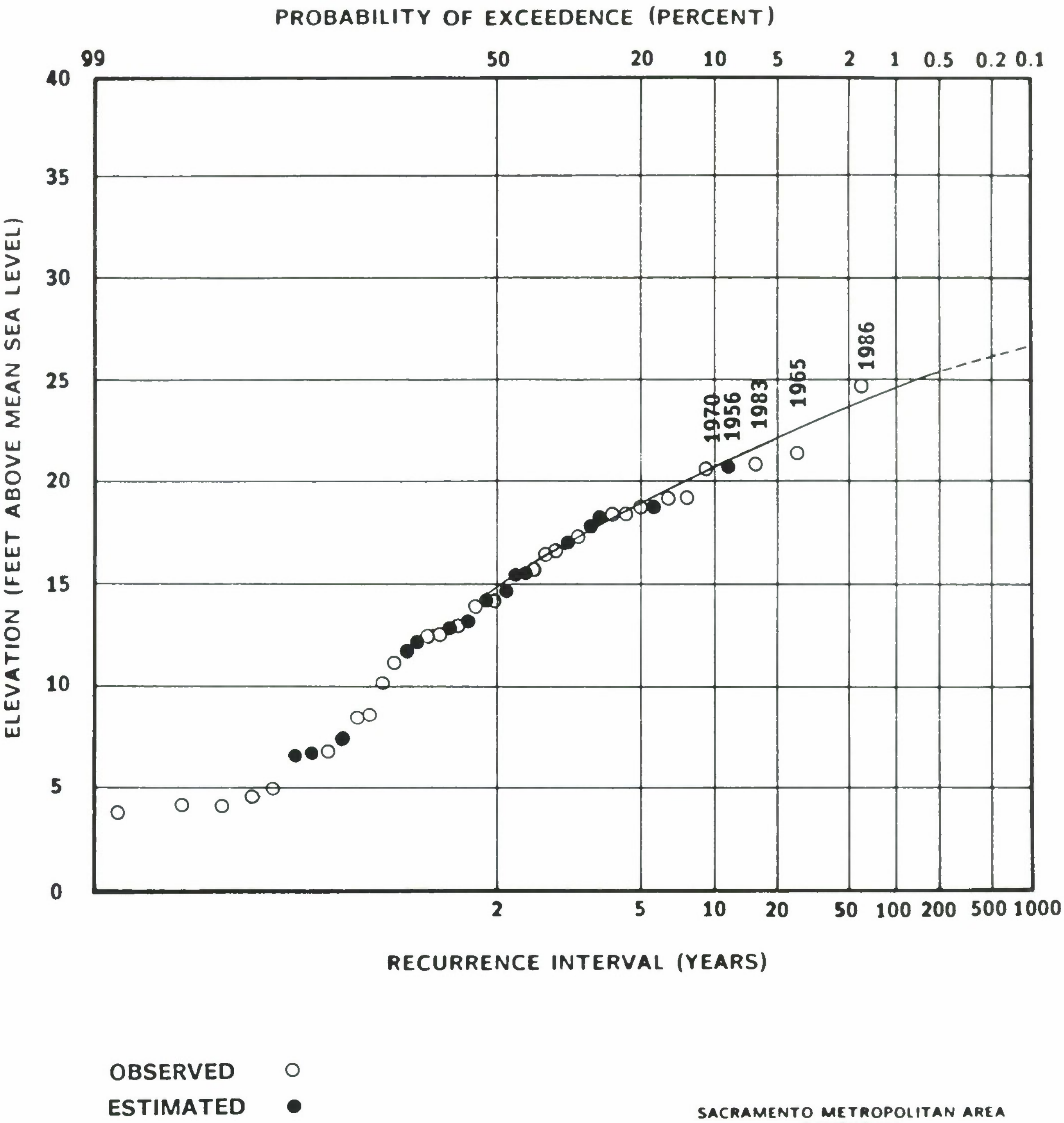
STAGE-FREQUENCY RELATIONSHIP

YOLO BYPASS NEAR WOODLAND

SACRAMENTO DISTRICT, CORPS OF ENGINEERS

June 1988

FIGURE 14



SACRAMENTO METROPOLITAN AREA
CALIFORNIA

STAGE-FREQUENCY RELATIONSHIP

YOLO BYPASS NEAR LISBON

SACRAMENTO DISTRICT, CORPS OF ENGINEERS

June 1988

FIGURE 15

TABLE 7

Observed Maximum Annual Stage Elevation
(Elevation in feet referenced to mean sea level datum)

Year	Sacramento River at Verona	Sacramento River at Fremont Weir (West End)	Yolo Bypass near Woodland	Yolo Bypass near Lisbon
1943	34.75	34.48	26.24	
1944	26.42	missing	18.65	
1945	32.77	32.80	24.20	
1946	33.83	34.01	25.29	
1947	28.05	30.12	12.64	
1948	31.07	32.14	21.84	
1949	30.56	32.00	21.44	
1950	32.18	32.91	23.27	
1951	34.06	34.22	25.77	
1952	32.83	33.19	23.54	
1953	33.44	34.13	24.14	
1954	31.82	32.90	22.50	
1955	22.89	26.16	12.82	
1956	36.81	36.72	28.19	
1957	31.61	33.10	22.29	
1958	35.47	35.70	26.64	
1959	32.26	33.30	22.74	14.53
1960	32.45	33.30	23.65	10.43
1961	27.05	29.98	16.91	13.29
1962	32.55	33.33	23.62	14.20
1963	35.14	35.42	27.39	19.60
1964	28.36	30.47	16.51	4.54
1965	36.65	36.53	29.07	21.69
1966	27.90	30.41	20.12	8.91
1967	33.88	34.22	25.11	17.59
1968	30.48	32.31	21.35	11.47
1969	34.11	34.37	25.33	18.72
1970	36.21	36.17	27.49	20.90
1971	31.00	32.48	22.23	12.70
1972	18.74	22.49	8.98	5.03
1973	31.00a	33.86	24.83	16.71
1974	34.90	35.10	25.94	18.75
1975	31.17	32.60	22.29	12.76
1976	17.80	20.94	8.75	4.25
1977	11.52	14.77	7.59	4.49
1978	32.52	33.39	24.26	15.94
1979	29.63	31.10	17.71	8.96
1980	35.12	35.31	26.55	19.07
1981	26.89	29.69	18.26	7.17
1982	33.72	34.25	25.12	16.92
1983	35.82	36.01	28.47	21.19
1984	35.42	35.62	26.68	19.49
1985	21.08	24.98	15.99	5.50
1986	39.11	38.54	31.46	24.88

a -- Gage height is an estimate based on daily average discharge.

TABLE 7 (continued)

Observed Maximum Annual Stage Elevation
(Elevation in feet referenced to mean sea level datum)

Year	Sacramento River above Sacramento Weir (North End)	Sacramento River at Bryte	Sacramento River at I Street	Sacramento River at Freeport
1943			28.85	
1944			17.60	
1945			27.64	
1946			27.28	
1947			18.18	
1948			22.50	
1949			20.36	
1950			24.55	
1951			30.14	
1952			26.84	
1953			25.46	
1954			23.73	
1955			13.89	
1956			28.67	
1957			25.75	
1958			27.62	
1959			21.64	
1960			21.39	
1961			15.89	
1962			22.85	
1963			28.52	
1964			17.31	
1965	29.28		29.36	
1966			16.80	
1967	28.37		27.40	
1968			20.80	
1969	29.02		28.18	
1970	28.81		28.24	
1971	23.26		21.79	
1972			10.29	
1973	27.70		26.74	
1974	28.23		27.18	
1975	23.42		21.85	
1976			9.19	
1977			5.18	
1978	24.93		23.70	
1979	22.78		21.43	
1980	28.40	28.61	27.83	
1981		17.50	15.68	
1982	28.25	28.58	27.70	21.27
1983	28.03	28.21	27.20	21.13
1984	28.43	28.49	27.40	20.74
1985		13.15	12.17	8.76
1986	30.56	30.65	30.58	25.11

new levee embankments, new and improved channels, floodgates, new storm drainage facilities and other land use changes. These changes have an impact on flood stages in the study area, but the magnitude (and whether the changes create an increase or decrease in flood stages) of the individual impacts has not been determined.

The stage-frequency curves were based on the period of record from 1943 through 1986 (44 years of record). For the Sacramento River at Fremont Weir/West End, 43 years of record were used (one year of record was missing as indicated in Table 7), and for Yolo Bypass near Lisbon the record from 1943 through 1958 was estimated based on a correlation with stages at the Yolo Bypass near Woodland. The stage-frequency curves generally indicate that the 1986 flood event had a recurrence interval of about 90 to 120 years. Based on previously published stage-frequency curves ("Sacramento-San Joaquin Delta Investigation, California," Corps of Engineers, July 1976) for the Sacramento River at Sacramento ("I" Street), the 1986 peak stage of 30.58 feet at "I" Street would have a recurrence interval of about 80 to 90 years. These recurrence intervals are considered to be reconnaissance level because the frequency analysis was based on unadjusted historic data. Historic peak stages were not adjusted to reflect the existing physical conditions in the basin, i.e., flood control improvements and land use changes.

By using the shorter, recent time intervals and median plotting positions in a stage-frequency analysis (16 data points for 1971 through 1986; 20 data points for 1967 through 1986), certain problems become apparent. The 1986 peak flood stage tends to plot as a high outlier at all gaging locations. Because the 1986 flood event plots as an outlier, it is difficult to determine an appropriate curve-fitting procedure and whether a weighted technique (weighted toward the 1986 flood event) should be used. In addition, the historic data plotted between the 2-year and 20-year recurrence intervals generally plot slightly above the stage-frequency curves shown in Figures 11 through 15 except for Sacramento River at "I" Street. At the "I" Street gaging station, the recent data tend to plot above and below the curves on Figure 13 and do not suggest that a potential change is needed. For the other stations, the recent data (the plotted data between the 2-year and 20-year recurrence intervals) tend to suggest that the stage-frequency curves previously developed should be modified slightly. (The modification represents less than a 0.5-foot difference in the stage for a given recurrence interval.) The modification also suggests that the 1986 flood event is not as infrequent as previously estimated.

Although the recent data reflect stages that are representative of existing conditions in the basin, there are other possible reasons why the shorter recent data plot above the previously developed stage-frequency curves. For example, it is possible that the 16 and 20 years of recently recorded flood stages are from a relatively wet time period within the available record. Regardless of the reasons, modifications that might be needed do not represent significant changes in flood stages for a specified recurrence interval.

The historic peak annual stages that have occurred in the study area result from various combinations of flows from three major river systems: the Sacramento (above the confluence with the Feather River), the Feather and the

American Rivers. For the February 1986 flood event, the peak flows and recurrence intervals are shown below.

Location	Peak Flows (cfs)	Recurrence Interval (years)
Sacramento River at Latitude of Ord Ferry	190,000	10
Feather River below Confluence with Bear River	290,000	80
American River at Fair Oaks	134,000	70

These recurrence intervals were based on expected probability adjustments, observed and estimated discharges and available discharge-frequency curves. The flood hydrographs from the three river systems and from various local tributary inflow (including pumped discharge) combined in the study area to create the peak stages indicated in Table 5. (As noted in Table 5, peak stages occurred at different times depending on the location in the study area.) The 1986 flood event was unusual in that the peak flows emanating from the American and Feather Rivers (and much of the local tributary inflow) occurred essentially at the same time.

During the 1986 flood event, Folsom Dam and Reservoir on the American River was filled to design capacity, and the USBR (the Federal agency that operates Folsom Dam and Reservoir) was operating the facility under emergency conditions to prevent excessive surcharging within the reservoir. If the February 1986 storm event had been any greater in duration or intensity, higher releases from Folsom Dam would have been required. Any increase in flow releases over those made during the February 1986 event would have seriously threatened the integrity of the levee embankment system along the American River downstream of the dam.

Based on the slopes of the stage-frequency curves, the difference in water surface elevation between a 100-year and 200-year flood event is about 1.0 foot in the study area. A 1.0-foot rise in flood stages above the February 1986 high water profile would put potential 200-year flood stages above, at or near the levee crown at various locations within and adjacent to the study area (see profile plots Plates 2 through 4 and freeboard observations in Table 6). It is possible that levee embankment failure (breaching) would not occur even with 200-year flood stages. However, for long duration flood events of this magnitude, severe wind conditions (particularly in the Yolo Bypass) and inadequate flood-fighting efforts, levee breaching would be very probable. With levee embankment failure in the study area, flood stages would probably not increase substantially over those indicated for the 200-year event.

For events greater than the 200-year flood, there is a high probability that a loss of control would occur at one or more of the major upstream flood control facilities. The ability to control releases to the objective outflow of 115,000 cfs at Folsom Dam on the American River is estimated to be a 63-year flood event. At Black Butte, Shasta, and Oroville Dams, the ability to limit releases to objective outflows is limited to about a 65-year,

100-year and 120-year flood event, respectively. If there is a loss of control at one or more of these major dams in the system, then it is highly probable that levee breaches would occur downstream of those facilities (upstream of the study area), and significant volumes of floodwater would be temporarily diverted. As a result, stage-frequency curves developed for the study area would probably not indicate any significant increase in flood stages beyond the 200-year flood event. Those curves presented in Figures 11 through 15 show a dashed line beyond the 200-year recurrence interval that is probably more representative of a flood condition in which there is no levee failure in, or upstream of, the study area (in theory, a condition of infinitely high levees).

Historic Flood Data

In a stage-frequency analysis, the plotting position of the largest peak flood stage becomes significant. In the analysis of the February 1986 flood, the plotting position of the peak stage was based on 43 to 44 years of systematic record. (The 1986 peak flood stage was the highest observed stage during that period of record at the locations given in Figures 11 through 15.)

Partial reservoir operation studies to date suggest that the 1986 flood event could be the largest flood event of the 1900's in the study area. For the Feather River at Oroville, operation studies determined flow duration values for unregulated conditions (essentially natural conditions) for the systematic record from 1902 through 1987. These values indicated that the 1-day, 3-day, 7-day, 15-day and 30-day maximum volumes for the 1986 event were the highest in that time period. In fact, the maximum volumes were 15 to 20 percent greater than the next largest flood event during that time interval. Although reservoir operation studies have not been completed for the entire Feather River watershed, it is probable that the 1986 flood event was also the largest on the Feather River because the intense portion of the storm band was generally centered from the North Fork of the Feather River (on the north) to the Mokelumne River (on the south). A similar condition existed on the American River at Folsom, where the 1-day, 3-day, 7-day, 15-day, and 30-day maximum volumes were the largest on record since 1905.

As previously noted, the 1986 flood event was unusual in that peak flows emanating from the American and Feather Rivers (and much of the local tributary inflow in the study area) nearly coincided as those flows merged within the Sacramento metropolitan area. This was due to the unique combination of hydrological and meterological conditions that occurred during the 1986 event. If some of the large historic storm events, such as the 1907 event, occurred today (with the existing system of levees, reservoirs, etc.), the peak flows would probably not coincide within the study area as they did in 1986.

Of the large historic flood events that occurred in the water years 1907, 1909, 1938, 1956, and 1965, the 1907 flood event appears to be closest in magnitude to the 1986 event. On the Sacramento River at Red Bluff, both the 1907 and 1986 flood events had flows of about the same recurrence interval (10-year), whereas on the Feather and American Rivers the 1986 flood event generated the largest flows (based on unregulated conditions). Although additional reservoir operation studies are needed to determine the stages that would result in the study area if these historic storm events occurred today,

available information suggests that the 1986 flood event could have created the highest flood stages since 1902 (87 years of record when considering the water years 1987 and 1988).

As a result, the median plotting position for the 1986 flood event could be about 0.8 (exceedance frequency in percent). This plotting position would make the 1986 flood event plot closer to the stage-frequency curves shown in Figures 11 through 15.

Information in House Document No. 81, "Reports on the Control of Floods in the River Systems of the Sacramento Valley and the Adjacent San Joaquin Valley, California," June 1911, indicated that the flood of March 1907 was the largest flood since 1862. Additional information contained in a letter report to The Reclamation Board from the City Commission of the City of Sacramento, dated December 18, 1913, stated that the peak flows of the flood of 1862 were estimated to be greater than those of 1907 on the American River by 60 percent, on the Bear River by 14 percent, on the South Fork of the Yuba River by 10 percent, on the Middle and South Forks of the Bear River by 13 percent, and on the North Fork of the Feather by 38 percent. As a result, it is quite probable that the February 1986 flood event was the largest flood event in the study area (based on unregulated conditions) since 1862 (or the second largest flood event in 127 years). For 127 years of record, the plotting position of the 1986 event could be about 1.3 (exceedance frequency in percent), and this would also make the 1986 flood event plot closer to the stage-frequency curves shown in Figures 11 through 15.

The Sacramento River Flood Control Project system was designed to provide capacity for a flood of the extent and duration of the March 1907 or January 1909 floods. Although significant land-use changes have occurred over time, including the construction of major flood control storage facilities, the February 1986 flood event equaled or exceeded design requirements at various locations within the study area.

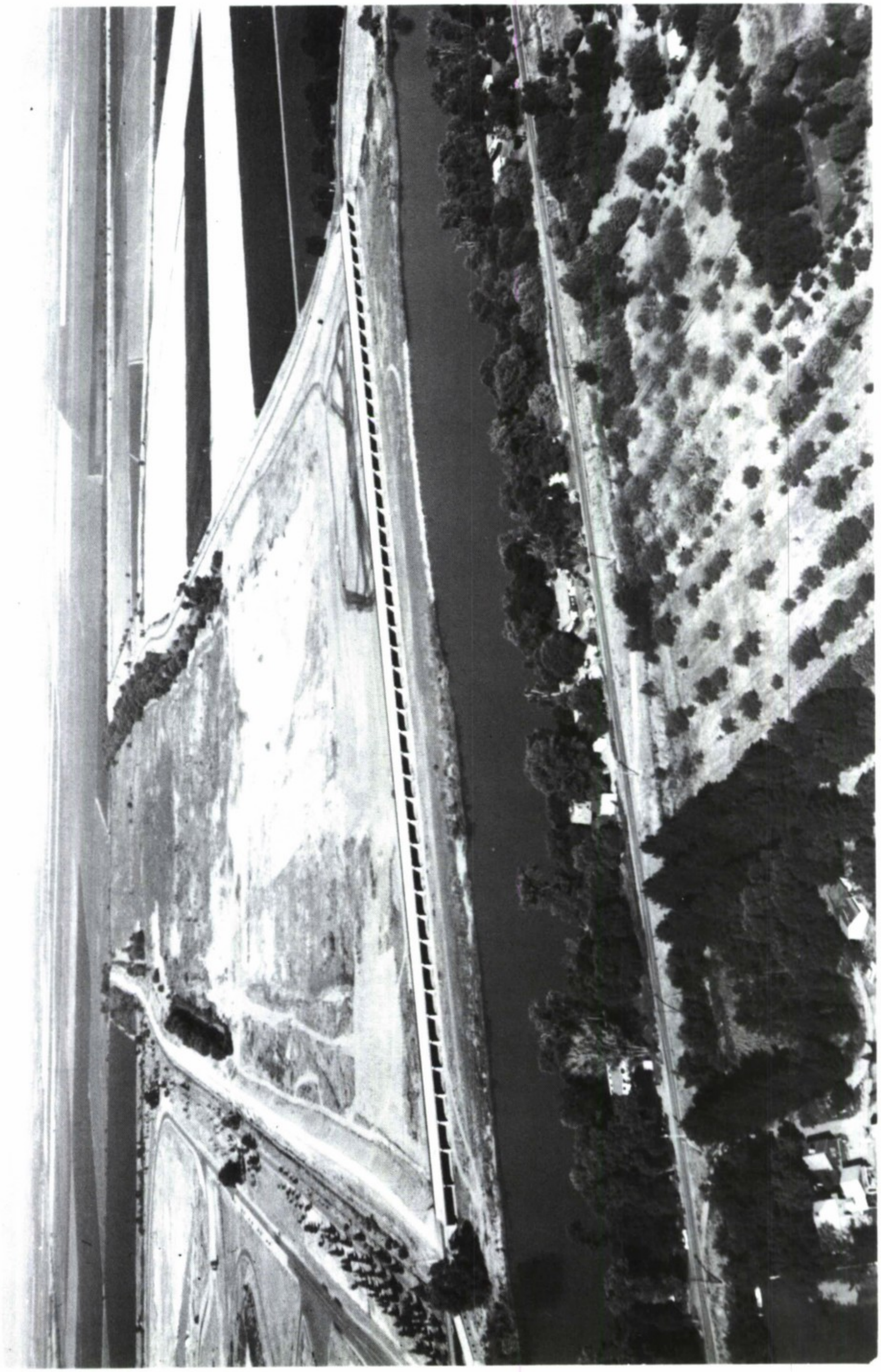
HYDRAULICS

Sacramento Weir

The Sacramento Weir (including the Sacramento Bypass) is operated by the DWR. The operational objectives are to limit flood stages in the Sacramento River, particularly downstream of the confluence with the American River, and to minimize or eliminate sediment deposition within the Sacramento River channel downstream of the confluence with the Feather River.

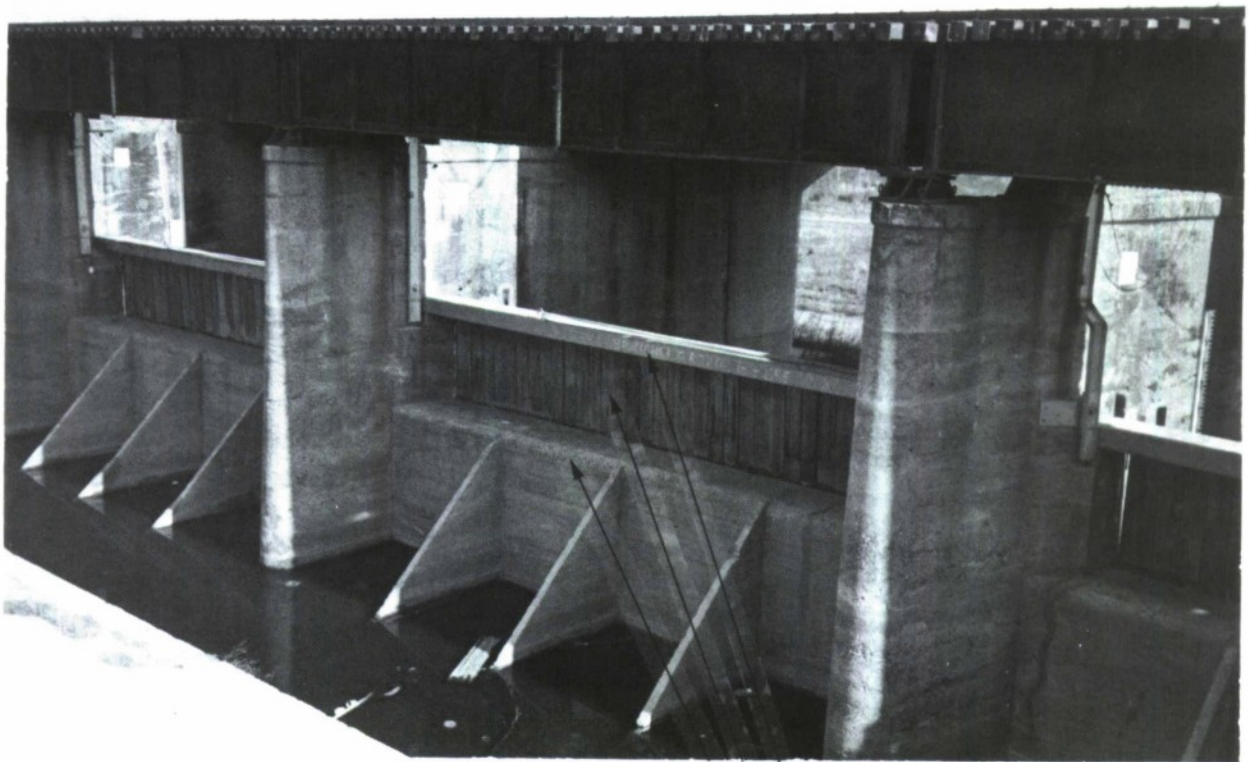
The Sacramento Weir is located on the west bank of the Sacramento River about 3 miles upstream of the confluence of the Sacramento and American Rivers (see Figure 16). The weir was designed to protect the city of Sacramento and adjacent areas from flood damage by providing a means to release excess floodwaters of the Sacramento and American Rivers into the Yolo Bypass system. Construction of the weir was initiated by the city of Sacramento in June 1916.

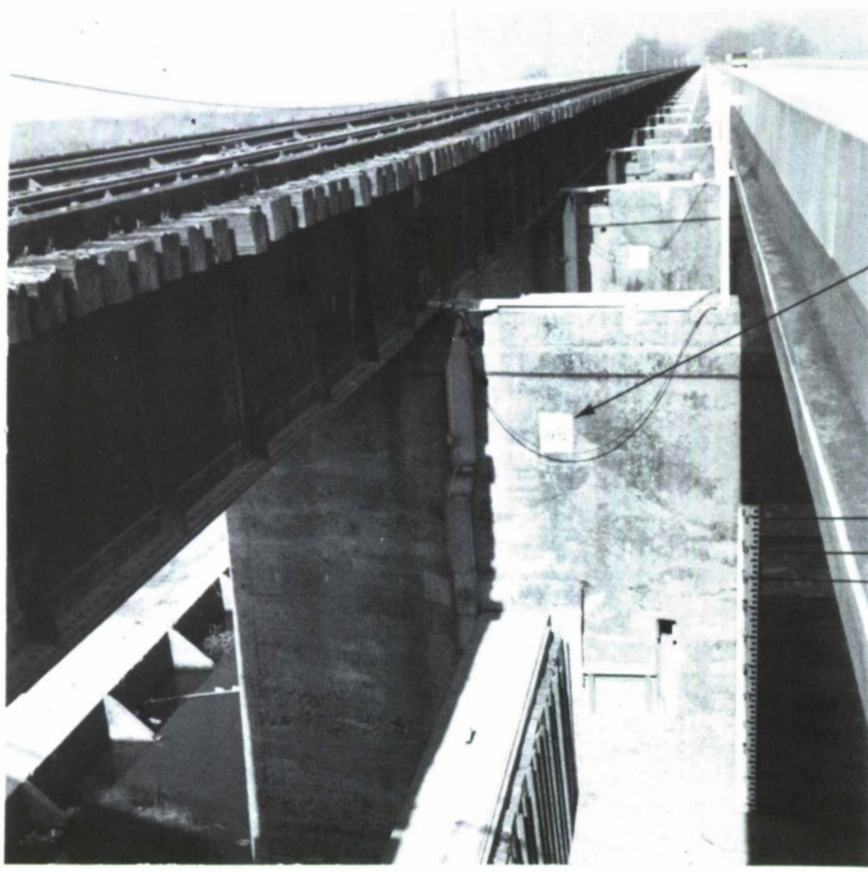
The weir is a reinforced concrete overflow structure with vertical (hinged) wooden stop boards that provide a moveable crest (see Figure 17). There are 48 weir sections, each 38 feet long. A 36-foot-wide highway bridge



RIVER MILE 63 - ENTRANCE TO THE SACRAMENTO WEIR AND SACRAMENTO BYPASS, 15 JULY 1982.

FIGURE 16





SACRAMENTO WEIR AND RELATED FACILITIES.

FIGURE 17

and a single track railroad traverse the length of the weir. Concrete abutments at each end tie into the west levee of the Sacramento River and the north and south levees of the Sacramento Bypass. The concrete weir crest is at an elevation of 21.2 feet (mean sea level datum), but with the hinged wooden boards lying flat on the concrete weir surface, the overflow crest elevation is about 21.5 feet. The top of the moveable crest is about 28.0 feet (elevation to the top of the steel channel beam holding the wooden stop boards in place).

In order to accomplish the stated objectives, DWR uses the following operation guidelines:

1. Opening of the weir gates (hinged stop boards) will not be initiated until a stage of 27.5 feet (mean sea level datum) is exceeded at the "I" Street gage.

2. As many gates as necessary will be opened so that the stage at "I" Street does not exceed 29.0 feet, insofar as possible.

3. Subject to provisions 1 and 2 above, the stage at the Sacramento Weir will be maintained during the gate opening period at 27.5 feet, insofar as practicable. (Stages are taken from the staff gage located near gate 48 as shown in Figure 17.)

4. Gates will be closed as the stage drops below 25.0 feet at the Sacramento Weir (as indicated by staff gage near gate 48). The gate closing will be conducted so that all gates are closed within as short a period as practicable.

February 1986 Flood. - As shown on the February 1986 stage hydrograph for the Sacramento River at "I" Street, the first gate on the Sacramento Weir was opened on February 17 at 0128 hours when the stage at "I" Street reached an elevation of 27.5 feet. The stage of the Sacramento River above the Sacramento Weir (measured by an automatic recording stage gage located about 550 feet upstream of the north end of the weir) at this time was about 28.1 feet. Both of these hydrographs indicated a drop in water surface elevation as more and more gates were opened. The final gate was opened at 2355 hours on February 17. The estimated peak flow over the weir was 127,700 cfs (peak stage of 30.56 feet indicated by the recording gage just upstream of the weir) on February 20 at 0115. The design flow for the Sacramento Bypass downstream of the Sacramento Weir is 112,000 cfs (see Table 4), and the design freeboard is 6 feet (3 feet of additional freeboard specified for the Sacramento Bypass to accommodate wave wash).

The weir opening is limited by the soffit elevation of the highway bridge, which is about 38.7 feet. (The soffit elevation of the railroad bridge is about 0.2 foot higher.) With the stop boards horizontal, the weir opening is about 17 feet (vertical difference) through the highway structure. At the time of the peak flow during the February 1986 flood event, the depth of water over the weir crest was about 9 feet, with about 8 feet of clearance remaining. (Figure 2 shows the railroad bridge at the Sacramento Weir near the peak of the February 1986 flood event. Pictures taken from the Sacramento Bypass levees indicate the clearance remaining to the soffit of the bridge structure.) Minimum levee embankment freeboard downstream of the weir and within the

Sacramento Bypass during the February 1986 flood was about 2.3 feet and 2.6 feet on the north and south levees, respectively (see Plate 4 and Table 6).

Based on the broad-crested weir formula and a C coefficient of 2.7, the weir opening could potentially convey up to about 350,000 cfs. The weir opening is not the controlling factor. In order to convey flows greater than the design capacity of 112,000 cfs, levee and channel modifications, both upstream and downstream of the weir, would be required. As indicated in the "American River Watershed Investigation, California," Corps of Engineers, January 1988, levee embankment build-up and armoring were used in designs greater than 112,000 cfs.

The sustained high flows and associated velocities in February 1986 caused significant damage to the concrete pavement just downstream of the weir crest as shown in Figure 8. Erosion and subsequent undercutting damaged the concrete pavement protecting the weir structure and south levee embankment of the Sacramento Bypass. Repairs were made to the damaged areas in the fall of 1986.

Fremont Weir

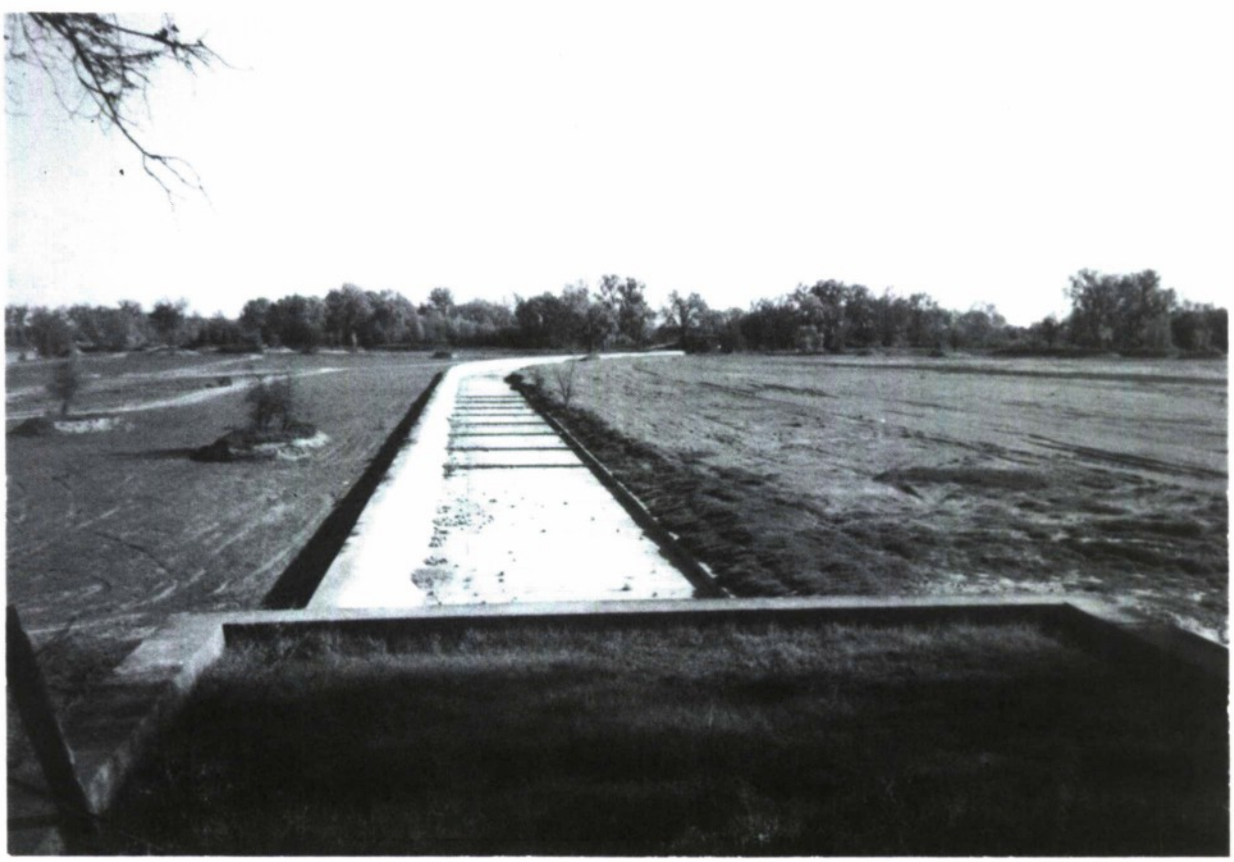
Fremont Weir is located in Yolo County along the west bank of the Sacramento River (between River Miles 81.7 and 83.4) about 22 miles upstream of the confluence of the Sacramento and American Rivers (see Figure 18). The primary functions of the weir are to provide a means to release overflow waters of the Sacramento River, Sutter Bypass and the Feather River into the Yolo Bypass and to prevent scouring of the bypass during floods. The adjoining levees provide direct protection to agricultural lands. The project design capacity of the Fremont Weir is 343,000 cfs. Construction of the weir was completed by the Corps in 1929.

The Fremont Weir is a fixed concrete weir that is about 9,120 feet long with an earthfill section (about 400 feet long) dividing the weir into two parts. The elevation of the crest of the concrete weir section is about 30.4 feet (mean sea level datum) based on recent surveys by the USGS, and the crown of the earthfill section is at an elevation of about 45 feet. A 25- to 35-foot concrete apron extends downstream from the weir face (see Figure 19). Also, about 55 to 65 feet of stone pavement is adjacent to and downstream of the concrete facilities for scour protection. Concrete abutments have been built at each end of the concrete weir sections and each end of the earthfill section. The elevation at the top of the concrete abutments is 39.0 feet, and elevations of the crowns of the adjoining east and west levee embankments are about 44.2 feet and 44.1 feet, respectively. These elevations are based on recent State surveys and subsequent levee crown profiles as presented in Plate 3.

February 1986 Flood. - Based on the high water mark profiles for the February 1986 flood event and a high water mark measurement by Reclamation District 1600, the maximum depth of flow over the east end of the weir crest was about 7 feet. About 1.5 feet of freeboard remained at the top of the concrete abutment. Minimum levee embankment freeboard for the east levee of the Yolo Bypass at and just downstream of the Fremont Weir (for the 1986 flood event) ranged from 6 to 8 feet, based on high water mark staking and surveys by the Corps. The estimated peak flow over the weir in 1986 was 341,000 cfs

RIVER MILE 82 - ENTRANCE TO THE FREMONT WEIR AND YOLO BYPASS, 15 JULY 1982.

FIGURE 18



ACCUMULATED DEBRIS AND SEDIMENT IN VICINITY OF FREMONT WEIR WAS REMOVED BY STATE AFTER FEBRUARY 1986 FLOOD.

FIGURE 19

(based on the DWR rating curve shown in Figure 20), compared to a design flow of 343,000 cfs. The estimated peak water surface elevation at the east end of the weir crest was 37.4 feet, compared to a design stage of 37.3 feet.

A comparison of the estimated 1986 peak flow and stage with the design flow and stage at the weir suggests that the weir was generally functioning as designed. The weir rating curve (discharge versus elevation) developed by DWR is based on a correlation between the water surface elevation observed at a stilling well about 550 feet upstream of the west end of Fremont Weir and a computed flow rate at a location about 5,800 feet downstream of the east end of the weir. (The computed flow rate is based on velocity and depth measurements taken by State personnel.) The rating curve shown in Figure 20 shows a solid line up to a flow rate of about 266,000 cfs, which represents the upper limit of the velocity measurements taken. The dashed line indicates an extrapolation or extension of the computed information. A 0.1-foot difference in stage in the extrapolated portion of the curve is equivalent to about 7,000 cfs. Based on the sensitivity of flow rate to changes in stage and potential error in the extrapolated portion of the rating curve, the estimate of the 1986 peak flow could easily be off by 14,000 to 21,000 cfs.

Water Surface Elevation Differences. - In addition, State and Corps field personnel have noted that a difference in water surface elevation exists between the west and east abutments of the weir. The 1986 peak water surface elevation for the Fremont Weir spill was 38.54 feet, based on an observation at a gage located about 550 feet upstream of the west abutment of the weir, whereas a high water mark at the east abutment of the weir indicated an elevation of 37.4 feet. Although no high water mark was available at the west abutment, this information indicates that a potential difference in water surface elevation exists between the west and east abutments of the weir. Any difference would be important in design considerations for the west levee embankment of the Yolo Bypass near the weir.

Sediment Deposition. - Another factor that can impact water surface elevations is sediment deposition. Field observations prior to February 1986 had indicated an accumulation of sediments (depositional build-up) near the west side of the Fremont Weir. Sediments deposited during prior flood events had gradually covered the stone pavement with up to 1 foot of soil material, and sediments deposited upstream of the weir were 2 to 3 feet higher than the weir crest in some areas. In addition, based on a DWR office memo dated April 9, 1985, the peak flow and stage in water year 1956 were 294,000 cfs and 36.72 feet, respectively. From the rating curve in Figure 20 (rating curve applicable for the February 1986 flood event), the stage for a flow of 294,000 cfs is 37.80 feet. This shift in the rating curve between 1956 and 1986 also suggests that aggradation could be occurring near the weir.

Due to this aggradation, DWR initiated a sediment removal program near the Fremont Weir (see Figure 19) in 1986 and continued the program in 1987. Additional sediment removal has been proposed by the State, but funds have not been available.

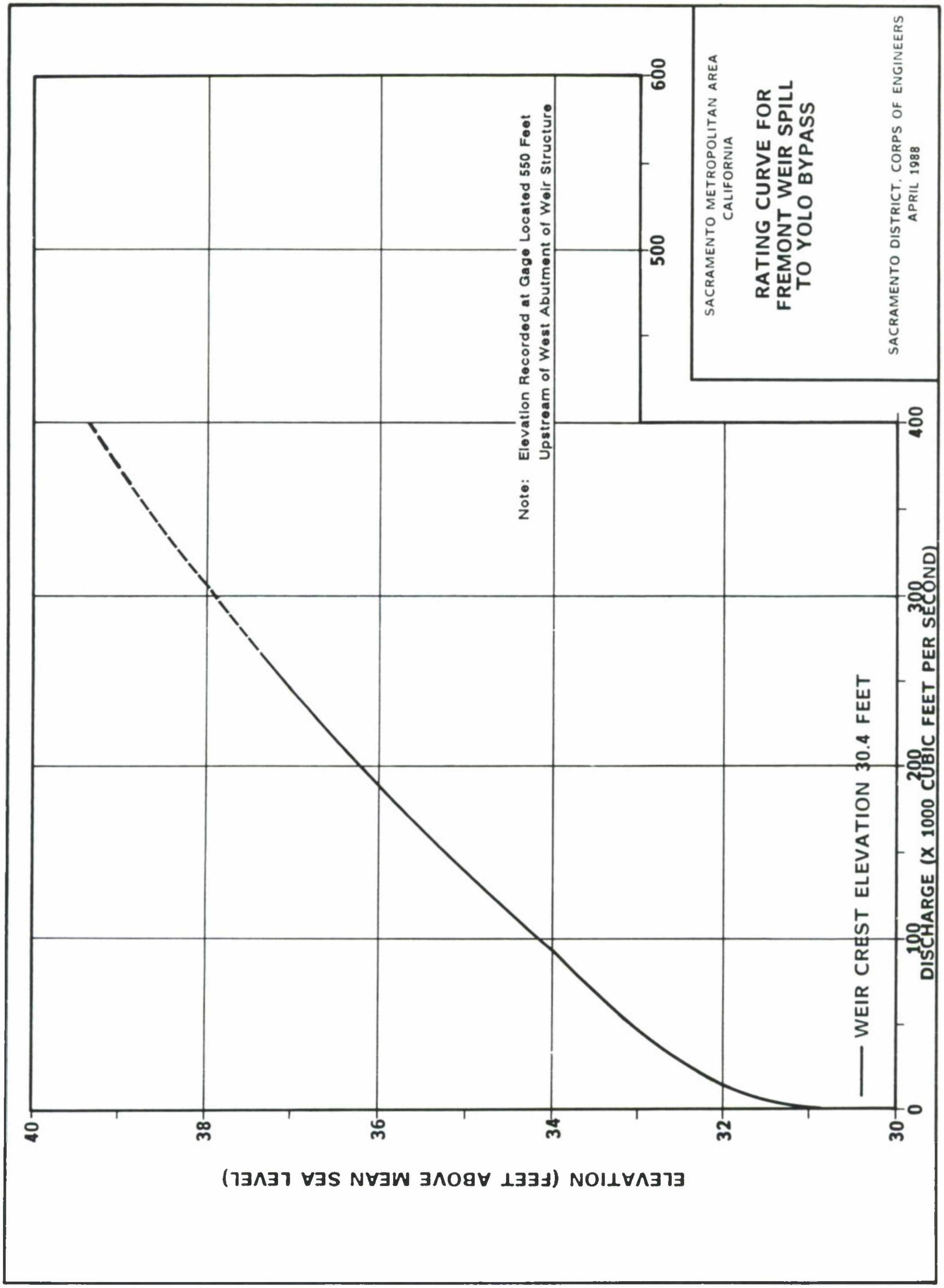

SACRAMENTO METROPOLITAN AREA
CALIFORNIA
RATING CURVE FOR
FREMONT WEIR SPILL
TO YOLO BYPASS
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
APRIL 1988
Note: Elevation Recorded at Gage Located 550 Feet
Upstream of West Abutment of Weir Structure
WEIR CREST ELEVATION 30.4 FEET
ELEVATION (FEET ABOVE MEAN SEA LEVEL)
DISCHARGE (X 1000 CUBIC FEET PER SECOND)
30
32
34
36
38
40
0
100
200
300
400
500
600

FIGURE 20

Hydrologic modeling results indicate that with the completion of the proposed sediment removal program, flood stages at the Fremont Weir could be reduced by as much as 1.3 feet. Also, flood stages on the Sacramento River near Verona could be reduced by as much as 1.5 feet by this program. Whether or not the model results are reasonable will be determined by a comparison of future flood measurements by DWR for the Fremont Weir spill. Since the model projections are significant, any new rating curve developed for the Fremont Weir should indicate a significant departure from the curve presented in Figure 20. DWR has indicated that they will take sufficient flow measurements when Fremont Weir spills in the future to more accurately establish a new rating curve.

Sutter Bypass

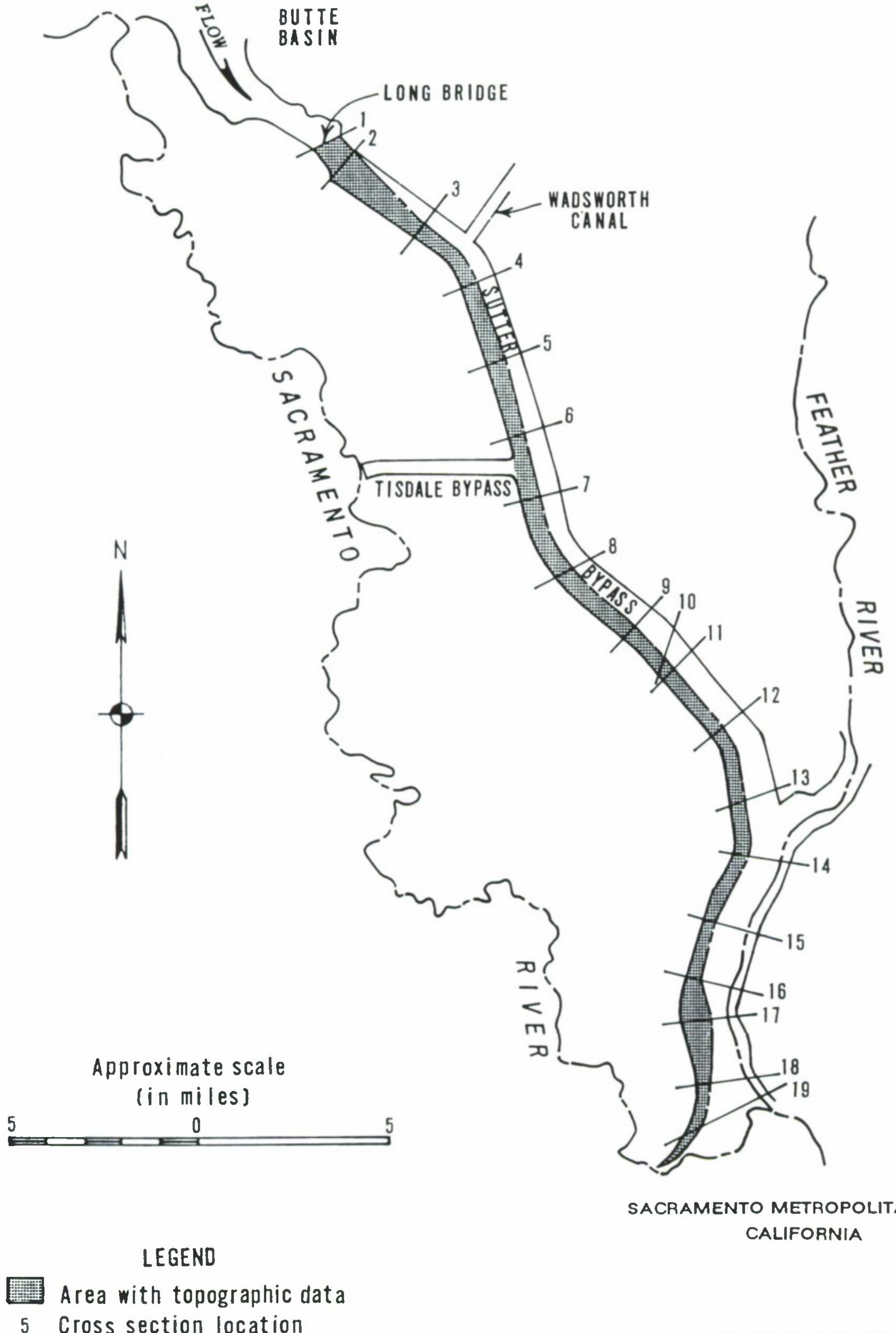
Although Sutter Bypass is not within the study area, the following information needs to be considered when formulating and evaluating alternatives.

Sutter Bypass is part of the Sacramento River Flood Control Project system. In addition to conveying Feather River flows, the bypass also provides a means to release overflow waters from the Sacramento River through Butte Basin and the Tisdale Bypass (see Figure 21). The Sutter Bypass varies in width from about 3,500 feet to 7,500 feet at the upstream and downstream limits, respectively. The design flow capacity varies from 150,000 to 380,000 cfs with a design freeboard of 5 feet.

Sediment Deposition. - Information developed by sediment transport studies for "Sacramento River and Tributaries Bank Protection and Erosion Control Investigation, California," Corps of Engineers, August 1983, indicates that sediment deposition within the Sutter Bypass could have a significant impact on flood stages, particularly near the confluence of the Sacramento and Feather Rivers. Topographic data from 1939, available for only a portion of the bypass, were compared with surveyed cross sections taken in 1979 by the USGS to determine net deposition in the shaded area on Figure 21. Net deposition for the period 1939 to 1979 was about 11,925,000 cubic yards (cy), or about 298,000 cy per year (402,000 tons per year), on the average.

Deposition and erosion between sections in the shaded area on Figure 21 are tabulated in Table 8. Since these data represent deposition for over 40 percent of the bypass surface area, total deposition was estimated by assuming a linear relationship between deposition and surface area; thus, about 740,000 cy per year (999,000 tons per year) of sediment were deposited in the bypass, on the average.

The majority of the sediments deposited in the bypass originate from Sacramento River overflow, either from natural overflow near the north end of Butte Basin or from overflow at Colusa and Tisdale Weirs. A significant portion of the sediments deposited in the lower end of the bypass originate in the Feather River system. There does not seem to be a build-up of sediments where the Feather River enters Sutter Bypass and at the confluence of the Feather and Sacramento Rivers. Between these two locations (cross sections 14 to 18 on Figure 21), a significant accumulation of sediments has been observed.



SACRAMENTO METROPOLITAN AREA
CALIFORNIA

SUTTER BYPASS

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
DECEMBER 1988

FIGURE 21

TABLE 8

Historical Deposition in Sutter Bypass 1/

Section Number	Erosion 2/ (Cubic Yards)	Deposition (Cubic Yards)	Net Deposition (Cubic Yards)	Net Deposition 3/ (Tons)
1				
	-492,400	4,100	-488,300 2/	-659,200 2/
2				
	-1,799,500	---	-1,799,500 2/	-2,429,300 2/
3				
	-5,800	845,900	840,100	1,134,100
4				
	---	1,582,400	1,582,400	2,136,200
5				
	---	1,510,700	1,510,700	2,039,400
6				
	---	1,939,400	1,939,400	2,618,200
7				
	---	2,352,100	2,352,100	3,175,300
8				
	---	1,614,500	1,614,500	2,179,600
9				
	---	488,500	488,500	659,500
10				
	---	87,900	87,900	118,700
11				
	---	926,800	926,800	1,251,200
12				
	---	895,700	895,700	1,209,200
13				
	-67,000	36,800	-30,200 2/	-40,800 2/
14				
	-44,000	175,400	131,400	177,400
15				
	---	946,300	946,300	1,277,500
16				
	---	818,900	818,900	1,105,500
17				
	-36,700	350,500	313,800	423,600
18				
	-136,300	---	-136,300 2/	-184,000 2/
19				
	-70,100	---	-70,100 2/	-94,600 2/
20				

Net deposition from 1939 to 1979 was 11,924,100 cubic yards, or about 298,100 cubic yards per year (402,400 tons per year).

1/ Represents deposition over approximately 40% of the surface area of Sutter Bypass.

2/ Material that was removed from system.

3/ Total deposition in tons was determined using a dry unit weight of 100 pounds per cubic foot.

December 1988

The estimated annual deposition of sediment in the bypass, 740,000 cy per year, on the average, represents about 0.30 inch in depth of deposited material if spread uniformly over the surface area of the bypass. Although the sediments do not accumulate uniformly over the bypass, this depth of material is significant when considering a time frame of 50 to 100 years. During the period from 1939 to 1979, the depth of sediment deposits represents about 1 foot of additional build-up. At present, sediment deposits are not being removed from the Sutter Bypass. However, material was removed from the bypass area during the early 1940's to build up the bypass levees to Sacramento River Flood Control Project standards.

The trend of sediment deposition in the Sutter Bypass is expected to continue. Since the deposition will increase the flood stages for a given flow rate, including stages near the Fremont Weir in both the Yolo Bypass and Sacramento River, flood control alternatives proposed for this area should consider designs that would accommodate the expected depositional build-up and potential gradient changes. For example, flood control alternatives incorporating levee raising near the confluence of the Sacramento and Feather Rivers should consider additional raising to accommodate future flood stages due to depositional build-up in the lower end of the Sutter Bypass.

Yolo Bypass

Yolo Bypass is also part of the Sacramento River Flood Control Project system. The primary function of the bypass is to convey excess overflow waters from the Sacramento River. In addition, the levee embankments provide direct flood protection to agricultural and developed lands including the city of West Sacramento. The bypass varies in width from about 7,000 feet near the Fremont Weir to about 16,000 feet at I-80. The design flow capacity varies from 343,000 cfs at the Fremont Weir to 500,000 cfs at the downstream limit, with a design freeboard of 6 feet. (Three feet of additional freeboard was specified to accommodate wave action.) Levee embankments are generally between 10 and 20 feet high, based on heights above the land surface on the landward side of the levee.

February 1986 Flood. - The design flow and design water surface elevation of the Yolo Bypass at the Fremont Weir are 343,000 cfs and 37.3 feet, respectively. During the February 1986 flood event, the estimated peak flow over the Fremont Weir was 341,000 cfs, and the peak water surface elevation at the east end of the weir crest was 37.4 feet. It appears that the weir was generally functioning as designed, within the limits of accuracy of the estimated flows and stages. For the Yolo Bypass near Woodland, the 1986 peak flow and stage also indicate that this part of the the Yolo Bypass can almost convey the design flow at the design water surface elevation. For the Yolo Bypass near Lisbon, the peak flood stage in 1986 was 24.9 feet, compared to a design water surface elevation of 23.2 feet. Although the report "American River Watershed Investigation, California," U.S. Corps of Engineers, Sacramento District, January 1988, estimated the 1986 peak flow at Lisbon to be 532,000 cfs, this value is now considered to be high based on revised estimates of upstream inflows. The 1986 peak flow at Woodland, using the rating curve developed by the USGS, was estimated at 374,000 cfs and included flows from Knights Landing Ridge Cut and Cache Creek, plus floodwaters

passing over the Fremont Weir. Flows into the Yolo Bypass between Woodland and Lisbon include the Sacramento Bypass, Willow Slough, Putah Creek and other minor local inflows. The 1986 peak flow in the Sacramento Bypass was about 128,000 cfs and in Putah Creek (at Winters) about 6,800 cfs. The 1986 peak flows in Willow Slough and other local drainage were relatively insignificant. Assuming that the peak flows are concurrent (not the case as indicated by Table 5 and from the observed peak on Putah Creek on February 21 at 0930 hours), the combination would suggest a peak flow in the Yolo Bypass at Lisbon of about 509,000 cfs. When considering just mean daily flows for February 20 (see Table 9) and neglecting the contribution from Putah Creek, the combined flow at Woodland (367,000 cfs) and Sacramento Weir spill (123,000 cfs) yields a flow of about 490,000 cfs. If a contribution from Putah Creek was added to the above mean daily flows, the resulting flow would be about 495,000 cfs. As a result, the 1986 peak flow in the Yolo Bypass at Lisbon was probably between 495,000 and 509,000 cfs. The design flow for the Yolo Bypass at Lisbon is 490,000 cfs, and this indicates that the bypass conveyed between 5,000 and 19,000 cfs more than the design flow in 1986. Because the bypass can accommodate a significant amount of additional flow for a small increase in water surface elevation, this indicates that the Yolo Bypass in the area of Lisbon cannot convey the design flow within the design water surface elevation.

Sediment Deposition. - Information developed from the sediment transport studies for "Sacramento River and Tributaries Bank Protection and Erosion Control Investigation, California," Corps of Engineers, August 1983, indicates that sediment deposition within the Yolo Bypass could have an adverse impact on flood stages and design flow requirements. Based on the sediment budgets contained in this report, long-term averages of about 580,000 tons and 150,000 tons of sediment are discharged annually over the Fremont and Sacramento Weirs, respectively, into the Yolo Bypass. Of the 730,000 tons of sediment discharged over the two weirs, about 429,000 tons (318,000 cy) are deposited annually in the bypass. Currently, about 200,000 tons of sediment are deposited in the Yolo Bypass by Cache Creek; the majority of this material is deposited in an area just downstream of the existing cobble weir. After the Cache Creek settling basin is modified, sediments from Cache Creek are not expected to deposit in the bypass, as noted in the report, "Cache Creek Basin, California," Corps of Engineers, February 1979. Additional sediments are transported into the Yolo Bypass from smaller tributaries and from agricultural return water.

Under existing conditions (no improvements at the Cache Creek settling basin), about 466,000 cy of sediment are deposited annually into the Yolo Bypass from Sacramento River overflow and from Cache Creek. If spread uniformly over the surface area of the bypass, 466,000 cy of sediment would represent a depth of about 0.05 inch of deposited material per year (2.5 inches of deposited material in a 50-year period).

The effect of sediment deposition on flood stages in the Yolo Bypass could be more significant than indicated because the sediments probably accumulate in specific areas. At present, sediment deposits are not being removed from the Yolo Bypass. Since the deposition will affect the flood stages for a given flow rate, flood control alternatives proposed for the Yolo Bypass area should consider designs that would accommodate the expected depositional build-up over time.

TABLE 9

Mean Daily Flows
February 1986 Flood Event

Location	Date	Flow (cfs)
Sacramento River at Verona	Feb 19	90,600
	Feb 20	92,300
	Feb 21	87,600
Sacramento River Freemont Weir Spill	Feb 19	303,000
	Feb 20	332,000
	Feb 21	265,000
Yolo Bypass near Woodland	Feb 19	279,000
	Feb 20	367,000
	Feb 21	308,000
Sacramento River Sacramento Weir Spill	Feb 19	121,800
	Feb 20	122,600
	Feb 21	96,600
Sacramento River at Freeport	Feb 19	115,000
	Feb 20	113,000
	Feb 21	103,000
American River at Fair Oaks	Feb 19	131,000
	Feb 20	114,000
	Feb 21	82,400

The USGS obtained cross sections of the Yolo Bypass in 1979. The locations of these cross sections could be resurveyed to determine changes in land surface elevation in the bypass since 1979. The resurveys could also be used to estimate depositional build-up. Whether or not resurveys are needed in the feasibility phase of the study would depend on the flood control alternatives selected and on the level of accuracy of the hydrologic modeling.

February 1986 Flood Stages. - The peak stages in the Yolo Bypass for the 1986 flood event generally occurred between February 19 and 20. Although adequate wind data is not available within or immediately adjacent to the Yolo Bypass during this period, wind data obtained from the Flight Service Station at the Executive Airport in Sacramento (about 7 miles to the east of the Yolo Bypass at the latitude of Putah Creek) indicated the following:

- Maximum (1-minute) wind speed on February 19 was from the southwest at 24 miles per hour.

- Maximum (1-minute) wind speed on February 20 was from the southwest at 18 miles per hour.

The action of wind on a body of water not only produces waves, but also induces a drag that moves surface water in the direction of the wind. Thus, the water becomes deeper on the leeward end of a body of water and shallower on the windward end. The increase in depth at the leeward end is referred to as wind setup. The observed maximum winds could have created wind setup of 0.1 to 0.2 foot on the east levee of the Yolo Bypass south of I-80 between February 19 and 20. Wind setup in the Yolo Bypass north of I-80 would probably have been less because of reduced fetch length and because the embankments of I-80 and the SPRR interrupt the movement of water.

The maximum winds could also have created 2 to 3.5 feet of wave run-up on the east levee of the bypass, depending on the slope and roughness of the levee embankment. Wave run-up is defined as the vertical distance above the still water level that a wave will run up the levee embankment slope. During a wind condition directed toward the levee, the still water level may be higher because of wind setup. Both wind setup and wave run-up are considered when designing the levee crest elevations in this reconnaissance level study.

Waves generated during the February 1986 flood event caused erosion of portions of the levee embankment at various locations in the study area. Emergency efforts were implemented during peak flows on the east levee of the Yolo Bypass as shown in Figure 22 to prevent further loss of levee embankment from wave action. The emergency work consisted of placing plastic over the surface area of the levee slope both above and below the water. Repairs have since been made to the damaged areas, and in some cases repairs consisted of placing rock and cobble revetment.

Minimum freeboards on the east levee embankment in the Yolo Bypass during the February flood were 1.5 feet at the Union Pacific Railroad, 1.3 feet just north of the Sacramento Bypass, and 2.0 feet just downstream of the Sacramento Bypass. (Minimum freeboard represents the difference in elevation between the still water level, including wind setup, and the levee crown.) In addition, Figures 23 and 24 show high flood stages at several bridges across the bypass. In the case of I-80, observations by Reclamation District 900

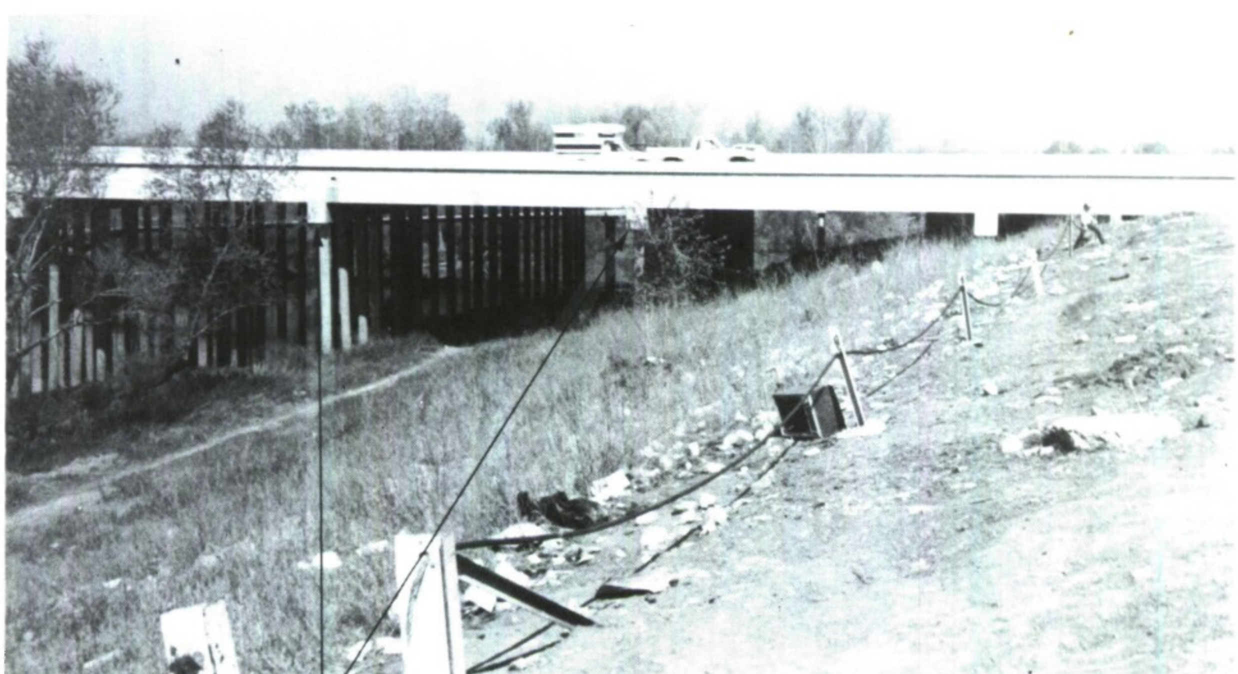
EMERGENCY WORK TO PREVENT FURTHER LOSS OF LEVEE EMBANKMENT FROM WAVE ACTION DURING FEBRUARY 1986 FLOOD (EAST LEVEE OF YOLO BYPASS).

FIGURE 22

HIGHWAY 16 AND UNION PACIFIC RAILROAD ON YOLO BYPASS NEAR PEAK OF FEBRUARY 1986 FLOOD.

FIGURE 23

EAST LEVEE OF YOLO BYPASS AT INTERSTATE 80 DURING FEBRUARY 1986 FLOOD.



HIGH WATER DURING FEBRUARY 1986 FLOOD WAS NEARLY TOUCHING BOTTOM OF TRANSVERSE BEAMS OF INTERSTATE 80 NEAR EAST LEVEE OF YOLO BYPASS.

FIGURE 24

indicated that high water during the February flood event was nearly touching the bottom of the transverse beams supporting the bridge decking. These transverse beams are 2.5 feet in depth, which suggests that the minimum freeboard under the bridge decking was between 2.5 and 3.0 feet.

Sacramento River at Verona

February 1986 Flood. - The Sacramento River Flood Control Project levee system was designed for a flow of 107,000 cfs and a design water surface elevation of 38.2 feet (mean sea level datum) at the confluence of the Sacramento River and the Natomas Cross Canal. During the 1986 flood event, the peak stage at this location was 39.1 feet, and the estimated flow was about 93,000 cfs, based on the USGS rating curve at this location. The 1986 flood event indicated that the levee system in this area cannot accommodate the design flow within the design water surface elevation.

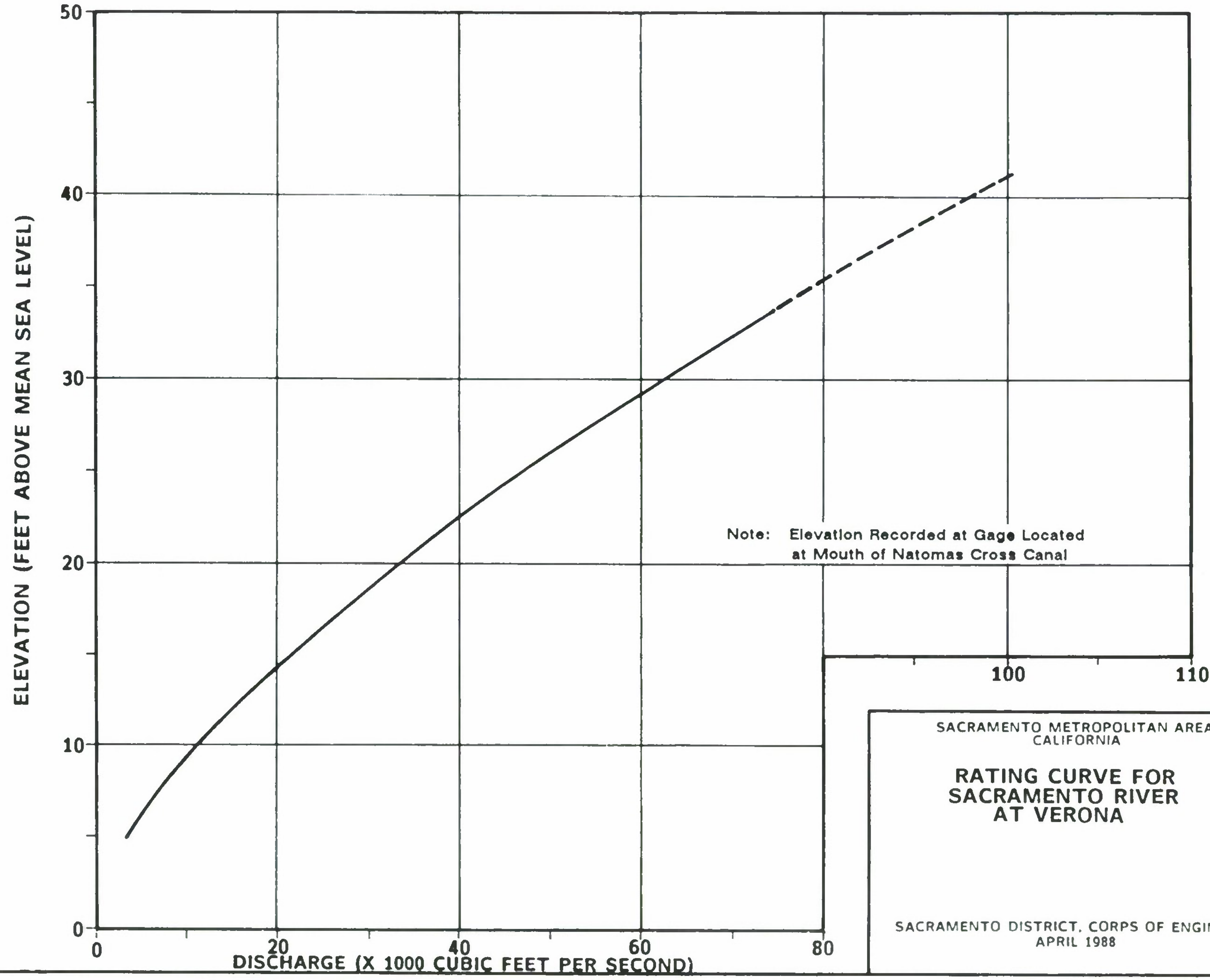
The problem of channel capacity of the Sacramento River in the vicinity of Verona was also presented in a letter report from The Reclamation Board to the Corps, dated March 6, 1985, as follows:

"However, the study also revealed that several miles of project levee in the upper reach of the study area could be overtopped by a design floodflow. Several more miles of project levee would not have the required freeboard of 3.0 feet.

Based on the results of this analysis, staff recommends that the Board place an indefinite moratorium on approval of developments that are currently allowed under the R.D. 1000 Standards for that reach of river extending from Channel Mile 63.0 (Sacramento Weir) upstream to Channel Mile 79.0 (Verona). This moratorium should remain in effect until such a time as additional studies and/or project modifications in the affected area shall warrant otherwise."

The USGS has a rating cross section about 2,700 feet downstream of the confluence with the Natomas Cross Canal. Discharge is determined at this location by taking various velocity and depth measurements. The discharge for a specific set of measurements is then correlated with the water surface elevation observed in a stilling well at the mouth of the Natomas Cross Canal. The rating curve for the Sacramento River at Verona is shown in Figure 25 and was applicable during the February 1986 flood event. The highest flow measurement was about 75,000 cfs in 1986. (The curve in Figure 25 is shown as a dashed line above 75,000 cfs and is an extrapolation based on engineering judgement.)

Based on this rating curve, about 90,000 cfs could be conveyed in this reach of the river at the design water surface elevation. For the design flow of 107,000 cfs, the extension of the rating curve indicates that this flow would overtop the levee embankment system on both the west and east levees of the Sacramento River in this area.



SACRAMENTO METROPOLITAN AREA
CALIFORNIA

RATING CURVE FOR SACRAMENTO RIVER AT VERONA

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
APRIL 1988

FIGURE 25

Because this reach of the Sacramento River cannot convey the design flow, it is possible that the channel has been aggrading (sediments accumulating on the bottom over time), thereby reducing the conveyance capacity. A comparison of the rating curves developed by the USGS for the Sacramento River at Verona over time (see Figure 26) indicates a trend in which the rating curve has continually shifted to the right. This trend is apparent throughout the range of observed flows and reveals that the conveyance capacity in this area has increased over the time interval indicated in the legend. The increased capacity is attributed to channel degradation, probably a combination of bottom scour and channel enlargement. The trend has been significant when considering a flow of 70,000 cfs:

Sacramento River at Verona

Rating Curve (years)	Stage (feet)	Flow (cfs)
1956-68	35.3	70,000
1968-69	34.6	70,000
1970-76	33.3	70,000
1986	32.4	70,000

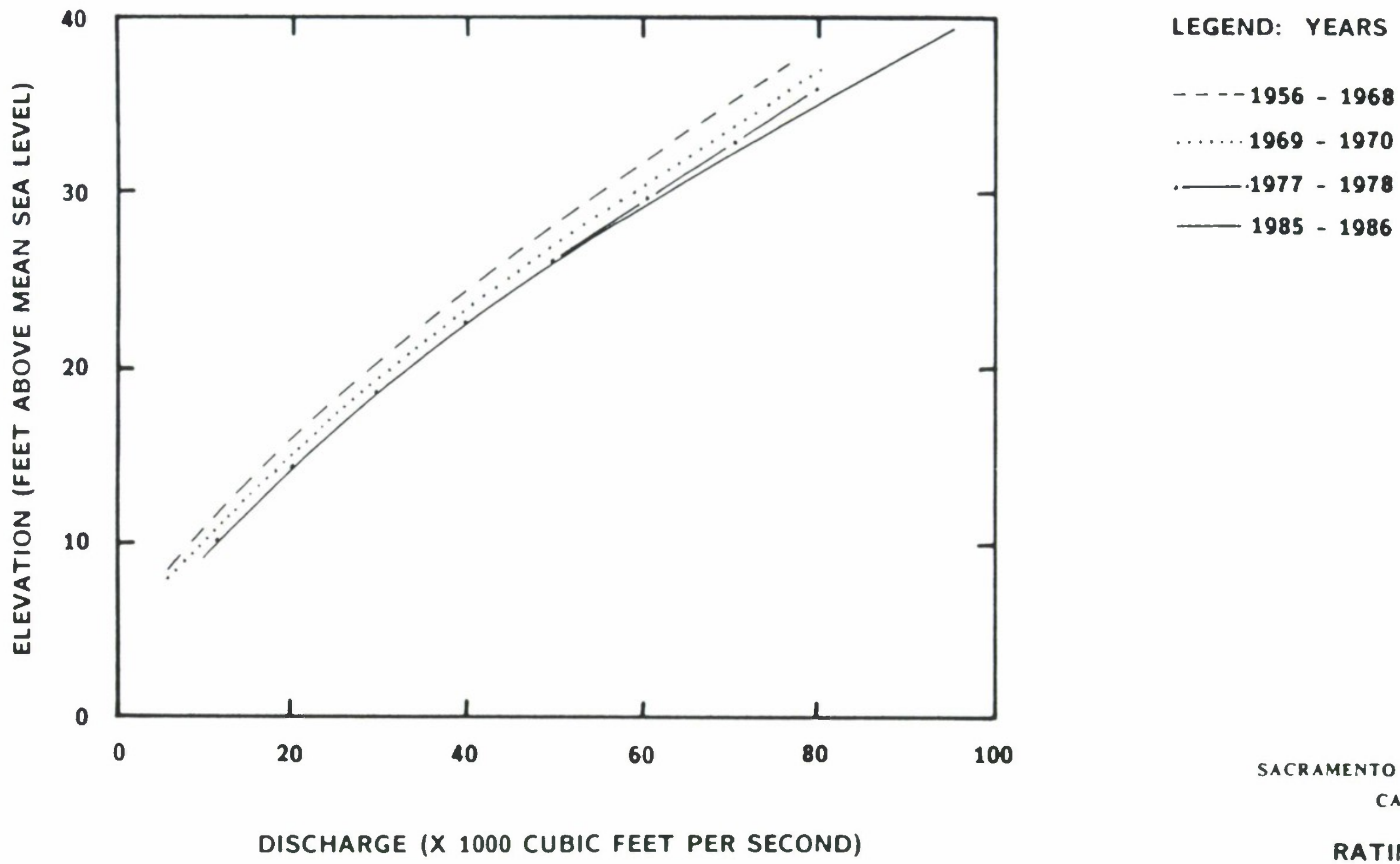
The rating curve data indicate that in 1956 this section of the river had significantly less capacity than it does now.

During the February 1986 flood event, the minimum observed freeboard was about 1.0 foot on the west levee embankment and 2.4 feet on the east levee embankment of the Sacramento River between Verona and I-5. Based on the stage-frequency curve (see Figure 12), the design level of flood protection, which incorporates 3 feet of freeboard, ranges from a 25-year to a 70-year flood event for the west and east levee embankments, respectively (see Table 10).

Why there has been degradation in this reach of the Sacramento River over the last 30 years is not known. There are many possible reasons, and some of them are listed below:

- Depositional build-up in the vicinity of the Fremont Weir has resulted in the diversion of more floodwater down the Sacramento River.
- Relatively greater volumes of water from increased rainfall, land use changes, etc., are now being conveyed through the system.
- The impact of historic hydraulic mining is no longer significant.
- Upstream dams and reservoirs are trapping sediments.
- Upstream regulation of flows is reducing downstream bank erosion.
- Bank protection work is reducing bank erosion.

Current and proposed work by the DWR to remove accumulated sediments adjacent to the Fremont Weir could have an impact on the continued degradation of the Sacramento River channel in the vicinity of Verona. During the



SACRAMENTO METROPOLITAN AREA
CALIFORNIA

RATING CURVES
SACRAMENTO RIVER
AT VERONA

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
JULY 1988

FIGURE 26

TABLE 10

Recurrence Intervals
for
Design Freeboard and Potential Levee Failure

Location Levee Reach	Design Freeboard 2/ (years)	Potential Levee Failure 1/ Existing Condition (years)	Potential Levee Failure 1/ With Structural Repair 3/ (years)
Natomas Cross Canal			
North levee	15	40 4/	
South levee	70	40	90
Sacramento River			
East levee (between American River and Natomas Cross Canal)	70	40	90
East levee (between American River and Freeport)	200 or more	90	200 or more
West levee (between Fremont Weir and Sacramento Bypass)	25	50 5/	75
West levee (between Sacramento Bypass and Freeport)	10	80 6/	90 7/
Yolo Bypass			
East levee (between Fremont Weir and Sacramento Bypass)	10	75	75
East levee (between Sacramento Bypass and Sacramento River Deep Water Ship Channel)	10	90 8/	90
Sacramento River Deep Water Ship Channel			
West levee (from Yolo Bypass levee to Lisbon)	20	150	150
Sacramento Bypass			
North levee	10	80	80
South levee	15	90	90

1/ For flood damage estimates. Actual levee failures may occur at higher or lower stages depending on flood duration, wave action, bank erosion, emergency efforts, etc.
2/ Corresponds to a water surface elevation which incorporates 3 feet of freeboard on Sacramento River and Natomas Cross Canal and 6 feet of freeboard on Yolo and Sacramento Bypasses.
3/ Structural repairs are those recommended under the "Sacramento River Flood Control System Evaluation," Corps of Engineers, May 1988.
4/ Based on structural similarities to the south levee of the Natomas Cross Canal.
5/ Based on structural similarities to the east levee of Sacramento River (Garden Highway). Structural problems with this levee embankment were not as severe as those of Garden Highway during the 1986 flood event.
6/ Probably less than the value cited in the "Sacramento River Flood Control System Evaluation," as indicated by notes 7 and 8 below.
7/ Recent levee crown surveys indicated a minimum freeboard of 1.4 feet near "I" Street during the 1986 flood event.
8/ Recent levee crown surveys indicated minimum freeboards for the February 1986 flood event different than those previously published.

February 1986 flood event (prior to the removal of sediments at Fremont Weir), floodwaters began to move over the weir and into the Yolo Bypass when the flow in the Sacramento River at Verona was about 58,000 cfs. This condition is not expected to change significantly even with the removal of the material in 1986 and 1987 due to defined flow channels that have been present in the past on the land surface upstream of the weir. The effective flow area is expected to change, however, due to the removal of the material and should improve the conveyance of floodwaters over the weir. Hydrologic modeling results indicate that the improved flow conveyance over the weir could significantly reduce flood stages along the Sacramento River from the Fremont Weir downstream to the Sacramento Weir. If the State removes additional sediment at the Fremont Weir, flood stages at Verona could be reduced by as much as 1.5 feet, based on the model results. Whether or not the model results are reasonable will be determined by a comparison of future floodflow measurements (greater than 58,000 cfs) by the USGS for the gaging station on the Sacramento River at Verona and by the State for the Fremont Weir spill. Since the model projections are significant, any new rating curve developed for Verona for flows greater than 58,000 cfs or for Fremont Weir should indicate a significant departure from the curves presented in Figures 20 and 25.

Sediment Removal at Fremont Weir. - If sediment removal at the Fremont Weir can be shown to be as effective as the model simulations indicate, flood control improvements proposed by the American River Watershed Investigation for the Natomas Cross Canal and the Sacramento River near Verona may not be needed (or may be reduced significantly in size and scope). If sediment removal at the weir is an effective alternative to other flood control improvements in this area, a continuous program of sediment removal would be needed since sediments accumulate gradually at the weir with each overflow event. A monitoring program similar to the State's surveying program at Colusa Bypass and sediment basin would be warranted. In addition, assurances from local interests would be required to maintain the existing flow conveyance within the Sacramento River channel downstream of Fremont Weir. Although this channel reach was degrading under conditions existing prior to the sediment removal at the weir, a maintenance program would still be needed to ensure that channel aggradation, if it did occur, would not adversely impact design levels of flood protection.

When the impacts of potential flood control alternatives are evaluated, particularly those alternatives that divert more of the floodwaters into the Yolo Bypass, it is important to determine whether those alternatives could result in depositional build-up in the Sacramento River downstream of the confluence with the Feather River. Coarse material, primarily sands, is pushed into the Sacramento River channel by flows emanating from the Feather (and Sutter Bypass) and American Rivers. If the flows are not sufficient in the Sacramento River to continually transport this coarse material downstream, channel aggradation will occur, resulting in higher flood stages and diminished flow capacity. One of the operational objectives of the Sacramento Weir and for the existing crest elevation of the Fremont Weir is to maintain flows in the Sacramento River to prevent depositional build-up.

Based on the 1986 flood event, depositional build-up does not appear to be a problem in the American River and in the Sacramento River downstream of the Sacramento Weir for the present mode of operation. In 1986, flows greater than the design flows were contained within the American River levee system at

or less than the design water surface elevation. A similar condition existed on the Sacramento River between the Sacramento Weir and Freeport. With the construction of Folsom Dam and Reservoir on the American River, the transport of coarse material downstream has probably been reduced. In addition, regulation of flows has probably reduced their ability to transport material and erode the channel banks in the American River downstream of the dam.

Sacramento River Deep Water Ship Channel

Information relating to the Ship Channel is contained in the Corps of Engineers' reports, "Sacramento River Deep Water Ship Channel Project," July 1949, and Supplement No. 1 to the General Design Memorandum of March 1986, "Sacramento River Deep Water Ship Channel," May 1988.

The Ship Channel is 30 feet deep and 200 to 300 feet wide and extends from Suisun Bay to Lake Washington (see Plate 5). As constructed, the west levee of the Ship Channel is now the east levee of the Yolo Bypass between Cache Slough and about River Mile 41.0 on the Ship Channel. Levee crown elevations for the west levee of the Ship Channel downstream to about Lisbon are shown in Plate 3. The Ship Channel levee crown elevation is about 2 feet higher than that of the Yolo Bypass where the two levees intersect just west of the Port. The east levee of the Ship Channel (between Cache Slough and River Mile 41.0) is the original project levee for the Yolo Bypass.

A navigational lock on the barge channel separates the Port facilities from the Sacramento River. If the gates of the lock are closed, water from the Sacramento River does not enter the Ship Channel at this location.

February 1986 Flood. - During the February 1986 flood event, the lock gates were closed. The peak water surface elevation on the Sacramento River side of the lock was about 30.2 feet. A float gage on the Port side of the navigational lock was inoperative during the peak stage period on the Sacramento River, but an estimate indicated a peak water surface elevation between 15.0 and 16.0 feet. An observer at the Port stated that the water surface elevation at 1600 hours on February 20 was just slightly below the dock surface elevation of 16.0 feet. Pictures taken of the Port (see Figure 27) also indicated that the flood stages were very near the dock surface. The same observer stated that the peak flood stage within the Port probably occurred between 1800 and 2000 hours on February 20. This peak flood stage was the highest on record in the Port area since construction of the facilities in 1963.

The 1986 peak flood stage recorded at the Ryer Island gage within the Ship Channel (about 200 feet downstream of Miner Slough on Cache Slough) was 14.23 feet at 1500 hours on February 20. Since floodflows from the Sacramento River flow freely to Cache Slough by way of Sutter, Miner, and Steamboat Sloughs, flood stages at the Ryer Island gage are related to stages (flows) in the Sacramento River in this area. In addition, flood stages at the Ryer Island location are also affected by flow in the Yolo Bypass, the San Joaquin River system and by tidal conditions.

SACRAMENTO RIVER DEEP WATER SHIP CHANNEL AND PORT FACILITIES NEAR PEAK OF FEBRUARY 1986 FLOOD.

FIGURE 27

During the February 1986 flood event, no water from the Sacramento River and Yolo Bypass entered the Ship Channel upstream of the confluence of Miner and Cache Sloughs. (However, floodwaters emanating from the Yolo Bypass did overtop the west levee embankment of the Ship Channel at about River Mile 20.0.) Local drainage from Reclamation Districts 900 and 999, which includes most of the area north of Miner Slough bounded by the Ship Channel and Sacramento River, was pumped into the Ship Channel upstream of Cache Slough. Maximum pumpage during the 1986 flood event was probably less than 400 cfs.

Since very little flow enters the Ship Channel above Cache Slough during a flood event, flood stages in this channel reach are expected to be similar to the flood stages observed at the Ryer Island gage or where Yolo Bypass floodwaters first merge with the Ship Channel. The time at which peak stages occur in this reach will generally be later than the observed peak time at the Ryer Island gage. (Significant increases in flood stages at the confluence of Cache and Miner Sloughs in a short period of time will create translatory wave movement through the Ship Channel toward the Port. The estimated wave travel time to the Port is probably a matter of hours.)

The recurrence interval associated with the February 1986 peak flood stage at the Port has not been analyzed. Since peak flood stages at the Port are primarily a result of flood stages (flows) in the Sacramento River downstream of the American River and in the Yolo Bypass, the recurrence interval is probably similar to that of the 1986 event of the Sacramento River at "I" Street or Yolo Bypass at Lisbon. For purposes of the reconnaissance phase of this study, the following peak flood stages and associated recurrence intervals are used for the Port:

Port of Sacramento

Peak Flood Stage (feet above mean sea level datum)	Recurrence Interval (years)
15.9	90
16.0	100
16.4	200

In addition, since the stage hydrographs remained relatively close to the observed peak for about 24 hours, it is assumed that the 100-year stages within the Port and on the Sacramento River near the Port are concurrent.

High ground on the north side and high ground and a local levee on the south side separate the harbor of the Port and barge canal from the developed areas of West Sacramento. High ground elevations on the north side of the barge canal range from 17 to 18 feet (mean sea level datum) based on April 1986 topographic mapping developed by the Corps. High ground and levee crown elevations on the south side of the barge canal range from 19 to 20 feet. If the flood stage exceeds 17 feet in the Port area, the potential exists for floodwaters to move north over the adjacent high ground into the developed areas of West Sacramento. If the flood stage exceeds 19 feet in the Port area, floodwaters could flow into areas of West Sacramento, both north and south of the Port facilities.

If a levee (levee could be on the Sacramento River, Sacramento Bypass or Yolo Bypass) protecting the area of West Sacramento north of the Ship Channel and barge canal is breached, floodwaters would flow into the area designated as Area A in Figure 28. Based on the volume-elevation relationship shown, about 20,000 acre-feet of water would flood Area A to an elevation of about 17 feet. At this elevation, floodwaters would begin to flow into the harbor and barge canal from the developed areas of West Sacramento north of these facilities. With the addition of floodwaters into the harbor and barge canal, flood stages in these areas would increase above an essentially static water surface elevation. The increased stages would create flow downstream through the Ship Channel toward the Ryer Island gage location.

Figure 28 also indicates that about 30,000 acre-feet of floodwater (if contained in Area A) would flood Area A to an elevation of about 19 feet. A hydraulic analysis indicated that if flood stages in the harbor also reached this elevation, about 20,000 to 40,000 cfs of floodwater could be conveyed downstream through the Ship Channel toward Ryer Island, based on a peak flood stage at the Ryer Island gage of 14.2 feet. If such a levee breach (or breaches) results in a flood stage of 19 feet in the harbor, floodwater would begin to flow south into the developed areas of West Sacramento south of the harbor (Area B on Figure 28).

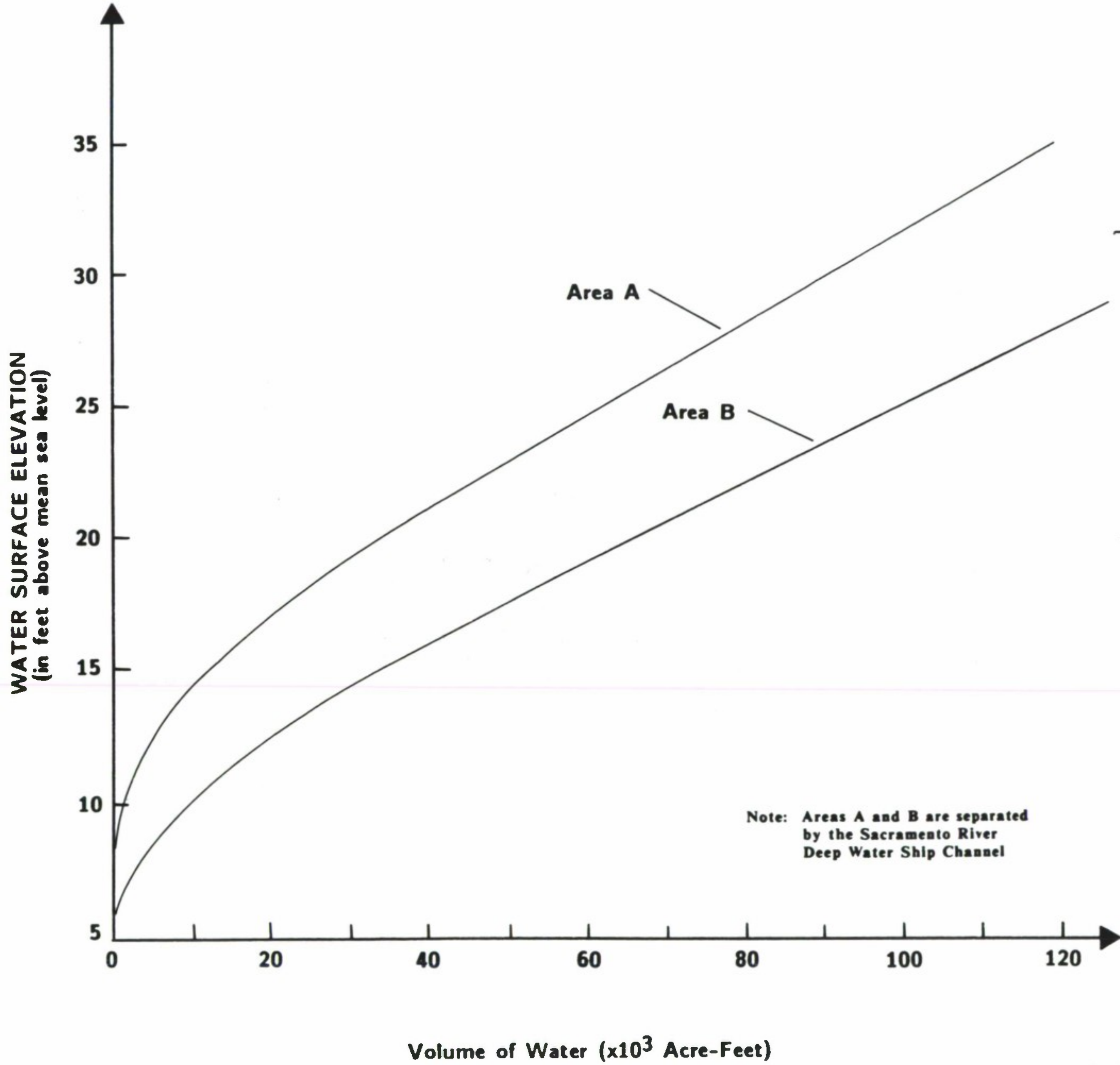
A single levee breach north of the harbor would probably not result in flooding in West Sacramento south of the harbor because the Ship Channel has the capacity to convey significant floodwater downstream. Two or more breaches in this area occurring at about the same time would cause flooding to occur south of the Port.

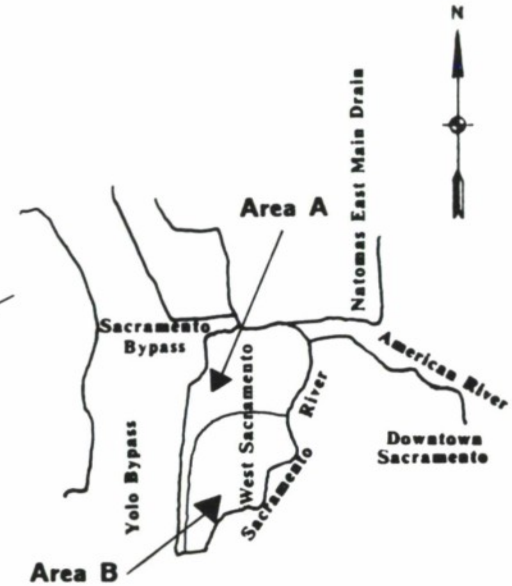
Flooding in Area B would be limited to the city of West Sacramento. A cross levee connects the west levee of the Sacramento River and the east levee of the Yolo Bypass and forms the southern boundary of the City (see Figure 29). The minimum crown elevation of the cross levee is about 24.5 feet.

Sacramento River at Freeport

The Sacramento River Flood Control Project levee system was designed for a flow of 110,000 cfs and a design water surface elevation of 25.4 feet (mean sea level datum) for the Sacramento River at Freeport. (The design flow for the Sacramento River from the confluence with the American River to Freeport is 110,000 cfs.) During the 1986 flood event, the peak flood stage at Freeport was 25.1 feet, and the estimated flow was about 117,000 cfs, based on the USGS measurements at this location. The 1986 flood event indicated that the levee system in this area can convey more flow than the design flow at the design water surface elevation.

Based on information presented in Table 4, the Sacramento Bypass and Sacramento River at "I" Street can also convey more flow than the design flow at the design water surface elevation. (Although the peak flow of the Sacramento River at "I" Street was not determined, the peak flow was estimated at 116,000 cfs. The only significant surface water runoff contributing to the Sacramento River flow between "I" Street and Freeport is local interior drainage that is pumped into the system. During the peak of the 1986 flood event, that pumpage was estimated at less than 1,000 cfs.) According to the American River Watershed studies, the American River can also convey more than the design flow at the design water surface elevation.





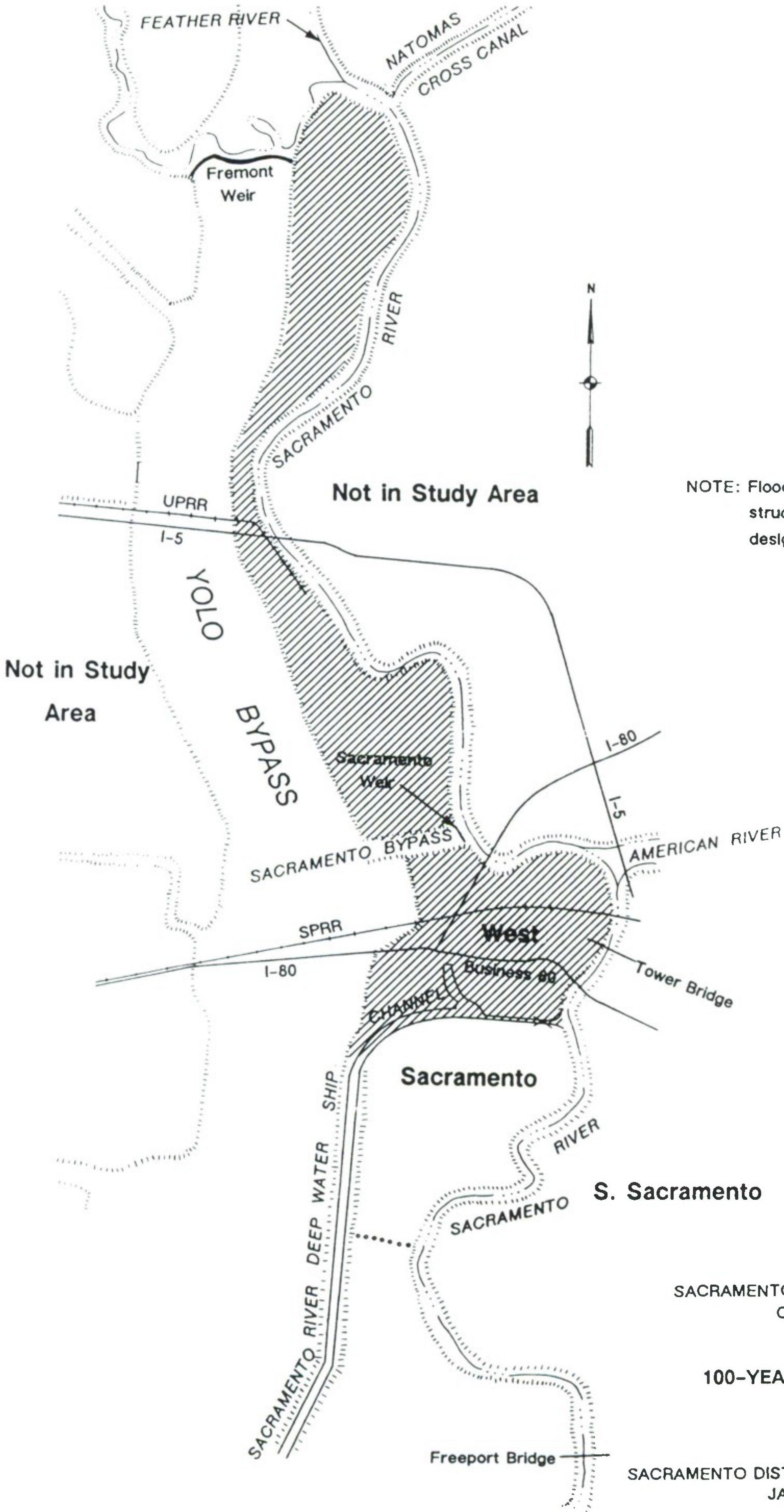
General location of site

Sacramento Metropolitan Area
California

STORAGE CAPACITY OF WEST SACRAMENTO AT VARIOUS WATER SURFACE ELEVATIONS

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
June 1988

FIGURE 28



LEGEND

FEDERAL LEVEES
PRIVATE LEVEES
100-YEAR FLOODED AREA

NOT TO SCALE

NOTE: Flooded area assumes levees are structurally stable under existing design conditions.

SACRAMENTO METROPOLITAN AREA
CALIFORNIA

100-YEAR FLOODED AREA

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
JANUARY 1989

FIGURE 29

It is probable that channel degradation has been occurring in the American River and the Sacramento River near the American River. As indicated in Chapter IV, "Sacramento River at Verona," channel degradation (combination of bottom scour and channel enlargement) has been occurring in the Sacramento River at Verona since 1956. Given the channel degradation at Verona and the fact that the American and Sacramento Rivers can convey more than the design flow at the design water surface elevation, channel degradation is probably occurring in the entire study reach of the Sacramento River. Changes in the physical flood control system tend to support channel degradation. These changes include the following:

- Additional upstream dams and reservoirs are trapping more of the sediments.

- Increased upstream regulation of floodflows is reducing downstream bank erosion.

- Additional bank protection work is reducing bank erosion.

- Relatively greater volumes of water are now being conveyed in the system because of land use changes.

As presented in the water surface profile of the Sacramento River for the February 1986 flood event (see Plate 2), the difference between the levee crown elevations and the high water mark profile indicates a minimum freeboard of about 4 feet on the east levee of the Sacramento River between the American River and Freeport. In general, the freeboard was between 5 and 8 feet. The location of minimum freeboard was near the Tower Bridge (see sheet 2 of Plate 2) where a floodwall exists. The floodwall is adjacent to high ground, and the crown of the floodwall is about 3 feet higher than the landward ground elevations. Failure of the floodwall could result in overland floodflows into the developed areas of Old Sacramento for major flood events, but potential flood damages would be insignificant when compared to a levee failure either upstream or downstream of the floodwall. Where there is a levee embankment in this reach of the river (for the east side of the Sacramento River between the American River and Freeport), about 5 feet of freeboard existed during the 1986 flood event. (For the Greenhaven area in south Sacramento, the minimum levee freeboard that existed during the February 1986 flood event ranged between 5 and 8 feet.)

For the city of West Sacramento (the city boundary extends from the Sacramento Bypass on the north to the private cross levee on the south as shown in Figure 29) adjacent to the Sacramento River, the February 1986 high water mark profile indicates minimum freeboards of about 1.4 feet near "I" Street and 3.6 feet near Business 80 (see Table 6). The levee crown profile (see sheet 2 of Plate 2) indicates that the location of minimum freeboard near Business 80 is high ground (not levee embankment) and is not significant when considering potential flood damages to West Sacramento. The levee embankment where the minimum freeboard was 1.4 feet represents a section of the levee about 500 feet in length that is depressed. A significant increase in levee embankment freeboard could be achieved on the West Sacramento side of the Sacramento River if this 500-foot levee reach was reconstructed and raised.

The reconnaissance level stage frequency curve on Figure 13, Sacramento River at I Street Bridge, indicates that the 1986 flood event was about a 90-year event on the Sacramento River downstream of the confluence with the American River. (Since there is only minimal inflow into the Sacramento River between "I" Street and Freeport, the 1986 flood event can be assumed to have the same recurrence interval in this reach of the river.) The difference in flood stage between a 90-year and a 200-year flood event is about 1.0 foot. Based on the above, the south Sacramento area, including Greenhaven, would have at least a 200-year level of flood protection from flooding by the Sacramento River, assuming that the levee embankments are structurally stable at existing design conditions (see Table 10). The city of West Sacramento adjacent to the Sacramento River would also have a high level of flood protection from flooding by the Sacramento River if localized depressed areas of the levee embankment are raised, assuming that levees are structurally stable at existing design conditions.

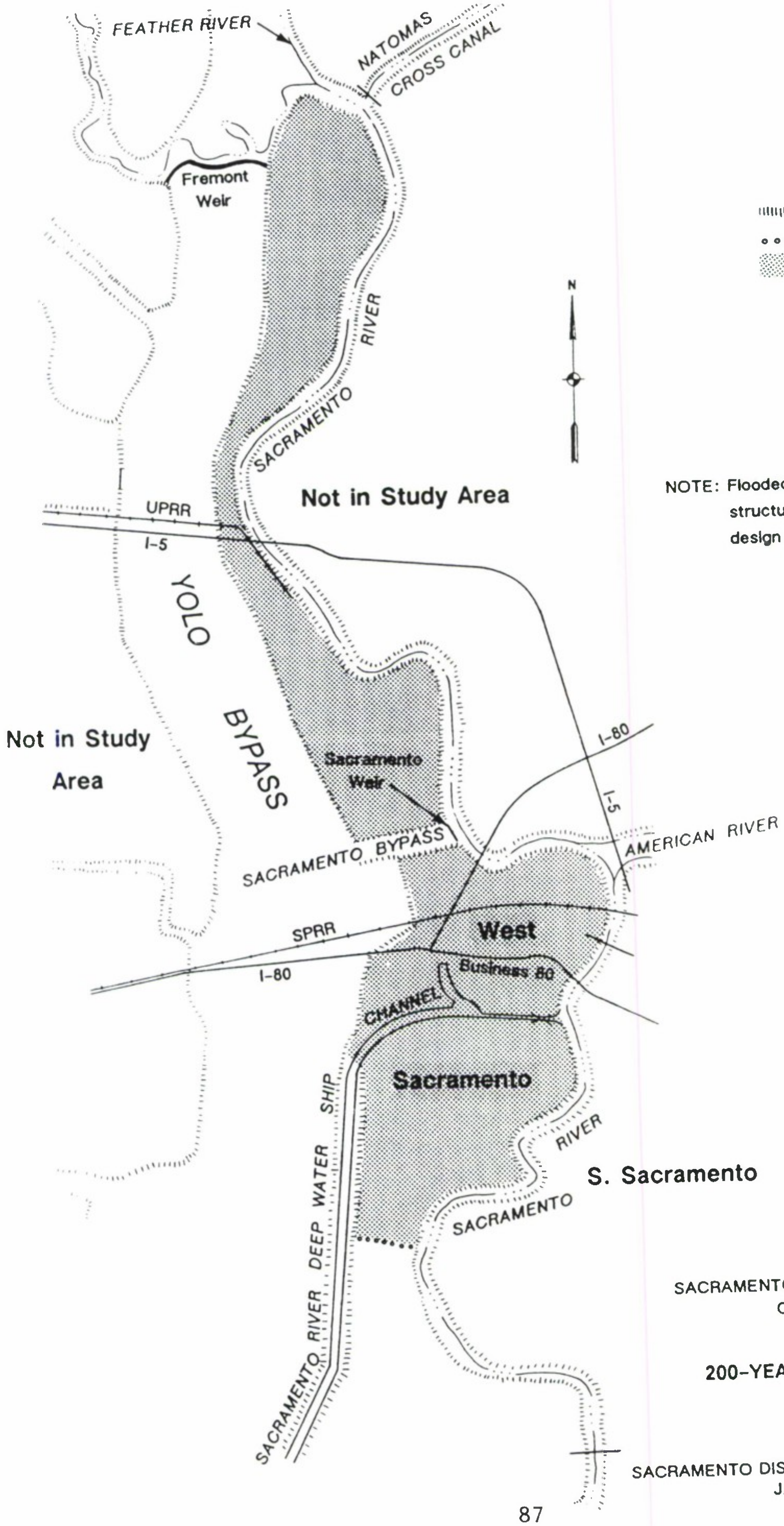
ECONOMICS

Flooded Areas

Potential flooded areas were determined within the study area to estimate flood damages for different frequency flood events. In all cases an assumption was made that levee embankments are structurally stable under design conditions. If the existing levee embankment is not structurally stable under design conditions, it was assumed that required repairs would be implemented as proposed by the Sacramento River Flood Control System Evaluation study. These repairs are considered part of the without project condition for this study. In addition, emergency flood fighting efforts were not assumed part of the without project condition because of the uncertainty that such efforts could be effectively implemented during a major flood event.

Based on these assumptions and engineering judgements regarding the impacts of flood stages, flood durations, wave action, bank erosion and remaining freeboard, it is estimated that a 100-year or 200-year flood event would flood the areas indicated in Figures 29 and 30. For the West Sacramento area, the minimum freeboard under without project conditions for the 100-year flood event is about 1.5 feet on the Sacramento River side, about 2.5 feet on the Sacramento Bypass and about 2.0 feet on the Yolo Bypass. The minimum freeboard represents the difference between the levee crown and the static water surface or the static water surface plus wind setup. (Minimum freeboard also assumes no levee breaching or overtopping upstream.) For the flooded area north of the Sacramento Bypass, the minimum freeboard under without project conditions for the 100-year flood event is about 1.0 foot on both the Sacramento River and Yolo Bypass. For a 200-year flood event, the water surface elevations would be about 1.0 foot higher than the 100-year flood elevations if no levee breaching or overtopping occurs (see the stage-frequency curves in Figures 11 through 15).

During the February 1986 flood event, sandbagging was required to prevent wave action from pushing floodwaters over the levee embankment on the Yolo Bypass side of West Sacramento. In addition, emergency flood fighting was also required to prevent the loss of levee embankment due to wave erosion on both the Sacramento River and Yolo Bypass sides of West Sacramento. Although the 1986 flood event was similar in peak flood stage to the expected 100-year flood event, wave action could be significantly greater. Increased wave



LEGEND

FEDERAL LEVEES

PRIVATE LEVEES

200-YEAR FLOODED AREA

NOT TO SCALE

NOTE: Flooded area assumes levees are structurally stable under existing design conditions.

SACRAMENTO METROPOLITAN AREA
CALIFORNIA

200-YEAR FLOODED AREA

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
JANUARY 1989

FIGURE 30

action would increase the severity and number of flood problems. In addition, with the loss of levee embankment due to wave action, there is a decrease in structural strength because of changes in the phreatic surface within the embankment material.

Although flood durations can be significantly different for flood events with similar peak stages, this reconnaissance phase of the analysis assumes that the expected 100-year flood event would be similar in duration to the 1986 flood. For flood events greater than a 100-year event, the ordinates of the stage hydrographs developed for the 100-year flood were increased proportionally based on the percent increase in the peak stage between the 100-year event and the event under consideration.

For the West Sacramento area, a single levee breach was considered appropriate for the 100-year flood event. Although more than one breach could occur, a single breach would draw the water surface elevation down in the Sacramento River, Sacramento Bypass, and Yolo Bypass adjacent to West Sacramento. This drawdown would significantly reduce the probability of more than one levee failure during the 100-year flood event. A single levee breach would probably occur on the Yolo Bypass side of West Sacramento because of the problems with wave action.

Flood Damages

Within the study area, levee failure (or overtopping by floodwaters) during major flood events would result in flooding of West Sacramento, parts of Sacramento and other non-developed areas adjacent to the Sacramento River. The potential flooded areas shown in Figure 30 contain about 25,000 acres and 27,000 people residing in 12,000 homes. The city of West Sacramento (south of Sacramento Bypass) contains about 13,000 acres, whereas the potential flooded area north of Sacramento Bypass contains 12,000 acres of croplands, about 40 houses and 150 people.

Flooded areas were delineated on USGS quadrangle maps. The Yolo County Assessor's roll was used to inventory and estimate the value of private structures within these areas. Since passage of California's Proposition 13, the Assessor's roll does not reflect current market values, but based on coordination with the Assessor's office, a 40 percent increase would provide representative market values for the study area.

Flood depths were estimated by locating each land parcel map (from the Assessor's roll) on the USGS maps and determining the difference between the average ground elevation and the water surface elevation for each flood event evaluated. Typical foundation heights were noted by visual examination and depth-damage relationships for each parcel map were adjusted accordingly using standard Flood Insurance Administration depth-damage curves. (Structures and contents were analyzed independently.) Elevation-damage relationships were then developed for the various flooded areas by combining the individual depth-damage curves for each parcel map within each flooded area considered.

Estimates of the potential flood losses were also made for the following categories: public and semi-public; traffic re-routing; emergency costs and agriculture. Public and semi-public damageable property values were based on

a recent Corps study in the south Sacramento area, "Report on Phase 1, Advanced Engineering and Design, Morrison Creek Stream Group, California," Corps of Engineers, March 1987. The public and semi-public areas within the flooded areas were measured and then multiplied by their value per acre. The value per acre depended on the type of development (whether a school, park, etc.). Traffic re-routing was considered on Interstate 80. Emergency costs were based on the cost of $35 per person per day depending on both duration of flooding and the anticipated time it would take before a family could move safely back into their home. Agricultural damages were based on a per acre damage by crop type.

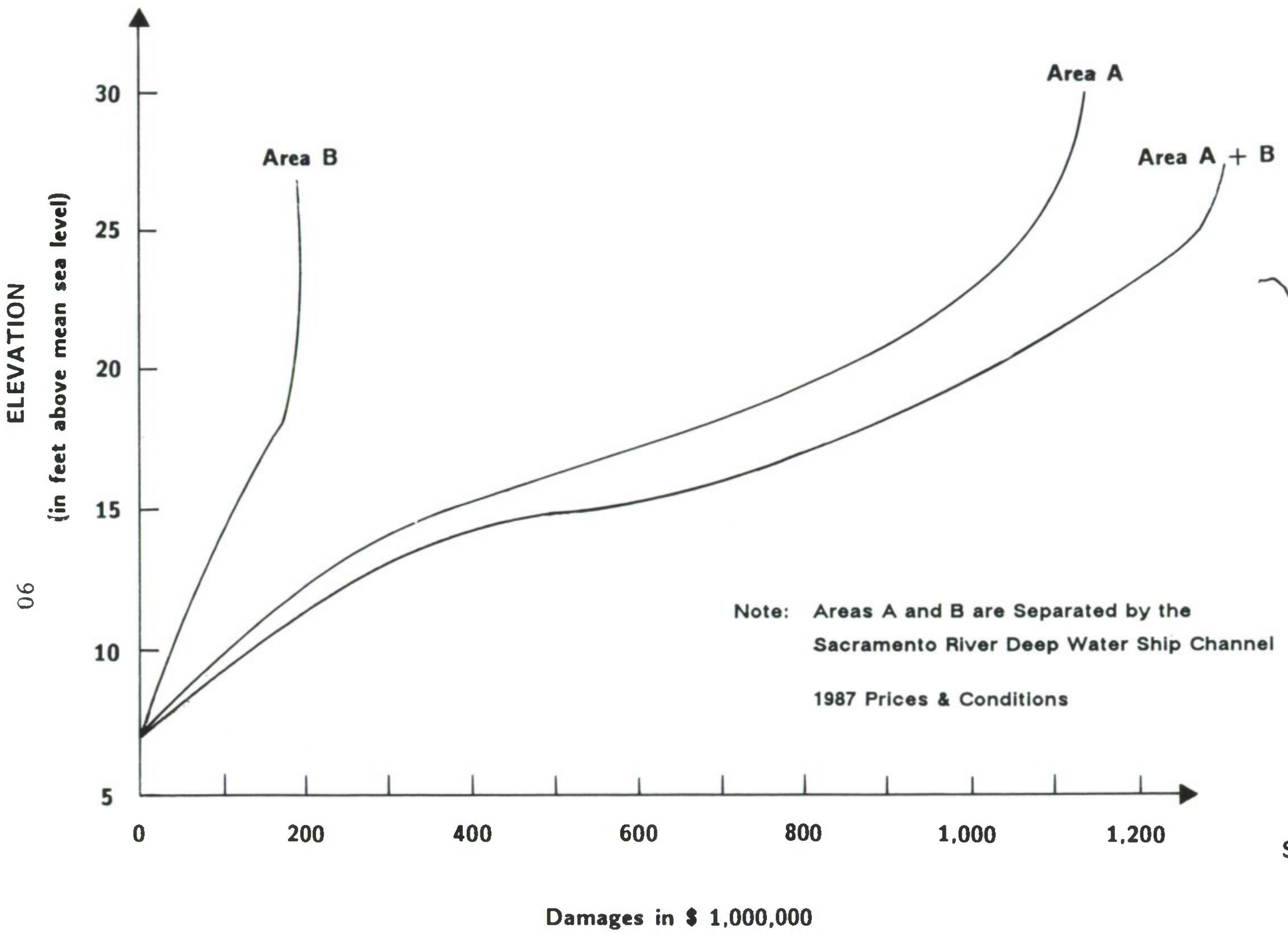
Based on the above information, elevation-damage relationships were developed as shown in Figures 31 and 32. The relationships indicate damages (in millions of dollars) for potential flood elevations under existing conditions for Areas A, B and C (damages were based on October 1987 price levels).

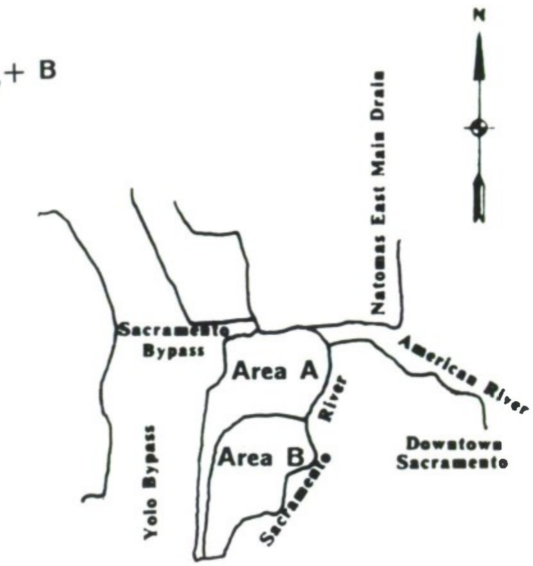
As shown in Figure 31, about $1.3 billion in damages would result from flooding in West Sacramento (Areas A and B) to an elevation of about 25 feet (mean sea level datum). This elevation of flooding would require that about 160,000 acre-feet of floodwater would have accumulated within the city limits of West Sacramento (see Figure 28). For Area C, about $16 million in damages would result from flooding to an elevation of about 30 feet.

A hydraulic analysis indicated that West Sacramento north of the Ship Channel (Area A on Figure 28) would be flooded to an elevation of about 20 feet during the expected 100-year flood event (with a single levee breach on the Yolo Bypass side). Flow through the breach and flow downstream in the Ship Channel would probably reach a balanced condition at about 40,000 cfs. The final levee breach width would be about 900 feet. The area south of the Ship Channel (Area B) would not have any significant flooding (for the 100-year flood event). For the expected 200-year flood event, more than one levee breach is probable. With multiple breaching, flooding would occur in West Sacramento both north and south of the Ship Channel to an elevation of about 23 feet.

The estimated flood damages in West Sacramento from the 100-year and 200-year flood events (under existing conditions) are $850 million and $1.2 billion, respectively. Average annual damages under without project conditions are about $12 million (assuming an existing 90-year level of flood protection, significant wave action and no flood fighting efforts).

A similar analysis of the flooded area north of the Sacramento Bypass (Area C) indicated potential flooding to elevations of 29 feet and 30 feet for the 100-year and 200-year flood events, respectively. A single levee breach in this area was considered probable for the 100-year flood event, while 2 or more breaches were used for the 200-year flood event. A single levee breach, with an average flow of 20,000 cfs, would have very little impact on reducing flood stages downstream in the West Sacramento area. Twenty thousand cfs represents a change in water surface elevation between 0.2 and 0.3 foot around the West Sacramento area. Two levee breaches during a 200-year flood event could reduce flood stages in the West Sacramento area by 0.4 to 0.5 foot. As





General location of site

Sacramento Metropolitan Area
California

WEST SACRAMENTO

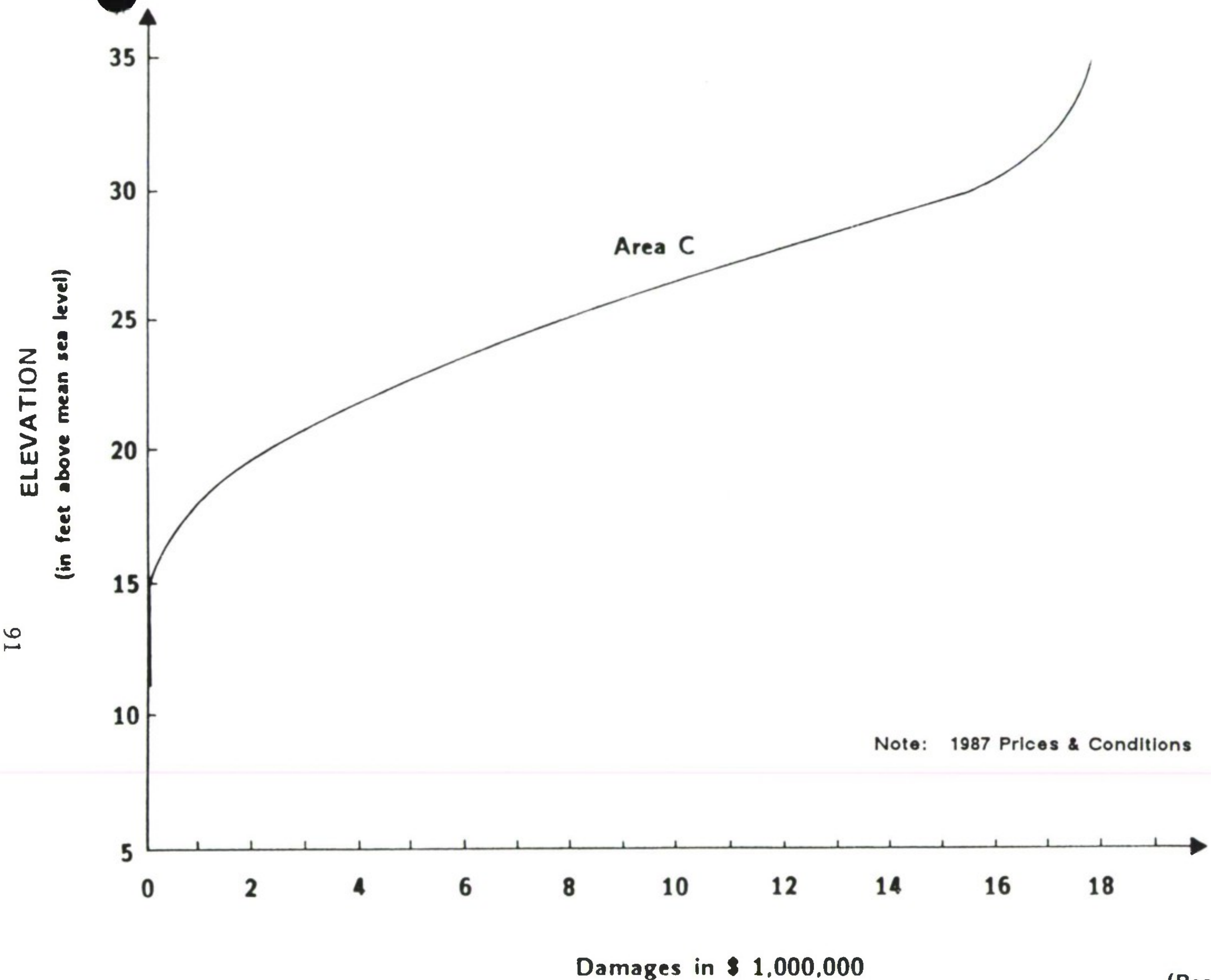
ELEVATION-DAMAGE

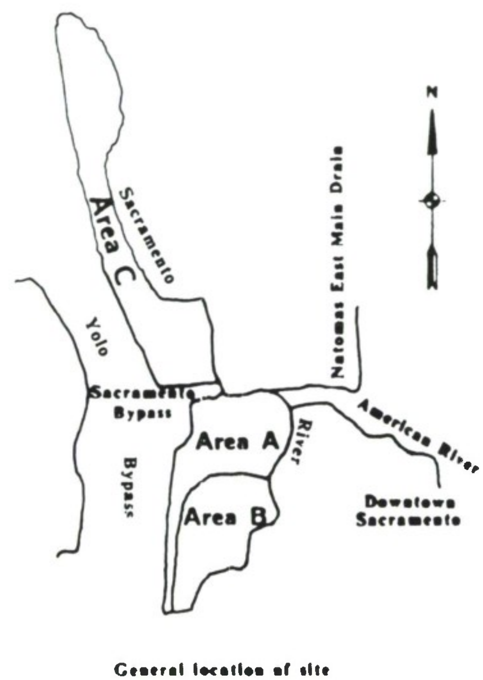
RELATIONSHIP

SACRAMENTO DISTRICT, CORPS OF ENGINEERS

June 1988

FIGURE 31





Sacramento Metropolitan Area
California

Area C

(Reclamation Districts 1600, 827, 785 & 537)

ELEVATION-DAMAGE
RELATIONSHIP

SACRAMENTO DISTRICT, CORPS OF ENGINEERS

June 1988

FIGURE 32

a result, a levee breach (or breaches) around Area C would not have a significant impact on reducing the downstream flood threat to West Sacramento.

The flood damages in Area C from the 100-year and 200-year flood events are $16 million and $17 million, respectively. Average annual damages under without project conditions are about $200,000.

The Flood Insurance Administration of the Federal Emergency Management Agency (FEMA) is currently reevaluating the flood hazard potential for the West Sacramento and surrounding areas. Based on reconnaissance level hydrology and the structural evaluation of the levee embankment system (presented in the report "Sacramento River Flood Control System Evaluation," Corps of Engineers, May 1988), West Sacramento and Area C do not have 100-year levels of flood protection. Because of the uncertainty of future development in these areas under the Flood Insurance Program, no future growth is being considered in the reconnaissance phase of this study. ER 1105-2-40, 2.4.11(b), "Economic Considerations," July 9, 1983, specifies that future growth considerations are not required if the benefit-to-cost ratio is above unity and if cost sharing will not be affected. Future growth scenarios would be considered in the feasibility phase when more definitive information is available on the consequences of the flood insurance designations on development.

Average Annual Damages

In order to estimate average annual damages under without project conditions (essentially existing conditions because future growth is not considered), potential levee failure scenarios were developed for different areas within the Sacramento metropolitan area. Estimates of the recurrence interval at which levee failures could potentially occur were based on performance during the February 1986 flood event, expected flood durations, wave action (including wave erosion), bank erosion, the ability of local entities to install floodgates at predetermined locations, magnitude and location of minimum freeboard, and stage-frequency curves. Locations and associated recurrence intervals of potential levee failure are presented in Table 10.

When using the historical performance of levees in evaluating potential levee failures, it should be recognized that physical changes that affect the hydrology and freeboard conditions in the study area have occurred since the February 1986 flood event. These changes include the following:

- Floodwall on the east side of the Sacramento River between "I" Street and Capitol Mall (Tower Bridge) has been reconstructed and raised.

- South levee of the Natomas Cross Canal has been modified.

- East levee of Yolo Bypass between I-80 and the Ship Channel has been modified.

- West levee of the Natomas East Main Drainage Canal between Main and El Camino Avenues has been modified.

- North levee of Arcade Creek has been extended upstream.

- Floodgates have been installed at locations on Dry Creek, Arcade Creek, and the Natomas East Main Drainage Canal where overflow of the levee embankment system occurred during the February 1986 flood event.

- Sediment has been removed upstream and downstream of the Fremont Weir.

Information on the general location of these modifications that are outside the study area are contained in the report "American River Watershed Investigation, California," Corps of Engineers, January 1988.

Table 10 indicates that the city of West Sacramento has about a 90-year level of flood protection, assuming that the structural repairs recommended in the "Sacramento River Flood Control System Evaluation," Corps of Engineers, May 1988, are implemented. Single or multiple levee breaching could potentially occur around West Sacramento during infrequent flood events (equal to or greater than the 90-year event) that would affect flood depths within the City. Flood routings indicate that the depths of flooding depend on the shape of the flood hydrograph at the location of the breach. For the reconnaissance phase of this study, stage hydrographs that were similar in shape to those shown in Figure 10 were used for the 90-year, 100-year, and 200-year flood events. Various potential scenarios of levee breach (or breaches) locations and widths suggest that peak flood elevations within West Sacramento could range from 20 to 23 feet for 90-year to 200-year flood events, respectively. With these expected flood elevations, flood damages within West Sacramento would be near the maximum shown in Figure 31. The resulting average annual damages under without project conditions would be about $12 million.

A similar analysis for Area C on Figure 32 suggests that average annual damages under without project conditions would be about $200,000. For Area C, it is assumed that structural repairs of levee embankments around this area would be implemented under a separate authority prior to development of any flood control alternative under this study. These structural repairs would probably raise the level of flood protection for this area to about a 75-year flood event. Detailed studies of the structural stability of the levee embankments around Area C will be considered in the future under the Sacramento River Flood Control System Evaluation.

CHAPTER V - PLAN FORMULATION

The process of developing and evaluating plans to resolve the problems and needs in the study is discussed in this chapter. The process includes establishing planning objectives, identifying flood control measures, developing and evaluating alternative plans, and identifying one or more potential plans in which there is a Federal interest.

PLANNING OBJECTIVES

The following planning objectives were established to address the problems and realize the opportunities identified in the study area and to serve as guidelines for the formulation and evaluation of alternative plans.

- Reduce potential flood damages along the Sacramento River and Yolo Bypass and in the urban areas of West Sacramento and south Sacramento.

- Preserve environmental and cultural resources in the study area.

FLOOD CONTROL MEASURES

Possible flood control measures were identified by the Corps and local interests at the onset of the study. These measures included modifying existing weirs and levees, diversion facilities, deepening or enlarging channels, and nonstructural measures. These measures were evaluated with respect to technical, economic, environmental and local acceptance criteria. A summary of the various flood control measures follows:

Modify Existing Weirs. - The purpose of modifying existing weirs is to allow greater volumes of floodwater to flow from the river system into the flood bypass system. The increased diversion could be accomplished by physical alteration of the weirs, such as lengthening or lowering, or removal or reoperation of weir gates. In addition, removing sediment that has deposited immediately upstream and downstream of the weirs could improve the effectiveness of the weirs.

The Fremont and Sacramento Weirs could be lengthened or lowered to allow greater volumes of floodwater to pass from the Sacramento River into the Yolo Bypass or Sacramento Bypass, respectively. In addition, the gates on the Sacramento Weir could be removed or reoperated to allow greater flow from the Sacramento River into the Sacramento Bypass.

Modify Existing Levees. - The purpose of modifying existing levees is to protect areas on the landside of the levees from flood inundation. Also, modifying levees will provide for greater volumes of floodwater to pass through the system without causing damage. Modification methods include raising or setting back existing levees.

Sections of the existing bypass levee system in the study area could be set back to increase the capacities of the bypasses. In addition, lower sections of levees could be raised to increase levels of flood protection.

Diversion Facilities. - The purpose of diversion facilities is to move floodwaters from one segment of a river or bypass system to another. Diversions can be accomplished by pumps, overflow weirs or other diversion facilities.

Water could be diverted from the Sacramento River or Yolo Bypass directly into the Ship Channel, thereby lowering the peak water surface elevation in the Sacramento River and/or Yolo Bypass in the area of the diversion.

Deepen or Enlarge Channels. - The purpose of channel deepening or enlargement is to allow greater volumes of floodwater to pass through the system. The increase could be obtained by deepening the river or bypass through dredging, removing flow constrictions or setting back levees.

Deepening the river or bypass through dredging would not provide a permanent solution and would require a commitment to monitor and dredge periodically in the future. Because of the uncertainties involved in determining aggradation following dredging, particularly in the Sacramento River, and in the ability to conduct maintenance dredging activities in the future, this measure was deleted from further consideration. In addition, because of the potential for catastrophic flood damages and loss of life, a permanent solution with significantly less uncertainty was considered necessary. However, embankment material could be removed from I-80 and SPRR in the Yolo Bypass and replaced with permanent bridge structures, and levees could be set back on the Yolo and Sacramento Bypasses.

Nonstructural Measures. - The purpose of nonstructural measures is to reduce flood damages rather than controlling floodwaters. Nonstructural measures may include such physical measures as relocating, elevating, flood proofing, or constructing floodwalls or levees to protect individual or small groups of structures. They can also include regulations or policies such as flood plain zoning and flood warning and preparedness planning.

The California Department of Fish and Game, in a letter dated July 14, 1988, requested that the following conditions concerning nonstructural measures be studied: (1) prevent future placement of fill to raise building pads above the 100-year flood plain and prevent construction of new residential and commercial structures along the waterside of the levees along the Sacramento River; and (2) item 1, plus remove all existing buildings and pads along the waterside of the levees along the Sacramento River. Based on current regulations governing construction along this reach of the river and because this reach of the Sacramento River has been degrading over time, these two nonstructural measures would not have a significant impact on levels of flood protection in the study area. As a result, they were not considered further.

Summary. - Preliminary analyses indicated that feasible plans of improvement could be developed by modifying existing weirs and levees, diverting floodwaters and/or increasing flow conveyance by removing embankment material or setting back levees in the study area. As a result, these measures were retained for further study.

DEVELOPMENT OF ALTERNATIVE PLANS

Formulation and evaluation of alternative flood control plans are based on the most likely conditions expected to exist in the future with and without the project. The without project condition is the condition expected to prevail if no action (no Federal participation in a flood control alternative) is taken. The with project condition is the condition expected to prevail with the proposed project in place.

Period of Analysis

The period of analysis for this study is considered to be 50 years from 1995 to 2045. The period includes the time required for project implementation. Construction of a project could potentially begin in 1995 (base year) and, depending on the alternative, could take from 1 to 4 years to construct. Most of the levee embankment improvement alternatives could be constructed in one year by using more than one contract to construct various parts of the project considering location, scope, etc. The actual base year will depend on Congressional authorization, funding and various other factors.

Without Project Condition

The without project condition includes the following:

a) The levee embankments of the Sacramento River Flood Control Project system are assumed to be structurally stable at the existing design water surface elevation. The Corps has initiated a comprehensive evaluation of the structural stability of project levees under the Sacramento River Flood Control System Evaluation. The Corps is also seeking approval to construct any needed modifications to bring the levees up to recommended design standards under the same authority. (Levee modifications under this program do not include any changes in the existing design levee crown elevations.) Since this levee modification work would be performed under a different Federal authority than the Sacramento Metropolitan Area study authority and has a high likelihood of being constructed, the work is considered to be part of the without project condition. The following conditions also apply:

b) Since there is no approved plan to change the authorized 400,000 af of seasonal flood control space at Folsom Dam and Reservoir or the existing flood control operation, these conditions are assumed to remain the same during the 50-year period of analysis.

c) The authorized Auburn Dam and Reservoir is not considered part of the without project condition.

d) Since the City of Sacramento has an approved emergency plan to install floodgates on the Sacramento River, Arcade Creek, Dry Creek and the Natomas East Main Drainage Canal, those gates are assumed to be installed during major flood events.

e) All flood control improvements approved and under construction by local agencies as of September 1988 will be considered to be part of the without project condition.

f) Because of the uncertainty of emergency flood fighting efforts during major flood events, potential flood fight measures are not considered part of the without project condition.

g) It is estimated that 100- and 200-year flood stages can occur within the study area without levee breaching or loss of control at major upstream dams and reservoirs. Flood stages greater than the 200-year event in the study area are not considered probable because of the increased potential of levee breaching and overtopping upstream of the study area. Once the ability to control releases is lost at one or more of the major flood control dams in the system, levee breaching would probably occur downstream of those facilities.

h) No significant residential, commercial or industrial development is expected upstream of the study area during the 50-year period of analysis. Additional development will occur around the Marysville and Yuba City areas (within the Feather River system), but such development is not expected to have a significant impact on flood stages in the Sacramento metropolitan area. Within and immediately adjacent to the study area, development would be minimal because most areas that could be developed would be mapped within the FEMA 100-year flood plain. Because of the uncertainty of the consequences associated with the current FEMA flood mapping, some future development adjacent to the study area is expected, but it is estimated that such development will not have a significant impact on the flood stages in the Sacramento metropolitan area. About 8,000 cfs of additional flow is required to change the flood stage for a major flood event by 0.1 foot in the study area. A significant amount of development would be needed to produce 8,000 cfs of additional flow into the Sacramento River Flood Control Project system. In addition, because of differences in timing, surface water runoff from developing areas within and adjacent to the study area would generally peak prior to flows coming from the upper Sacramento and Feather River systems. As a result, even if significant amounts of new development occurred, it would probably have only a small impact on flood stages within the study area.

With Project Condition

The with project condition involves the implementation of one or more flood control alternatives. Each alternative plan would provide an increase in the level of flood protection for the Sacramento metropolitan area and will be compared to the without project condition over the period of analysis.

Alternatives Requested by Local Interests

Based on the interest shown by the Sacramento County Board of Supervisors in a meeting held on February 18, 1988, the Corps agreed to evaluate the feasibility of using the Ship Channel for flood control purposes. This local interest was in conveying excess floodwaters from the Sacramento River via the lock and barge canal of the Ship Channel.

DESCRIPTION OF ALTERNATIVE PLANS

Several flood control alternatives were considered for further analysis. These alternatives focused on five major areas: modification of Fremont Weir

and Yolo Bypass; modification of Sacramento Weir and Bypass; diversion of floodwaters into the Ship Channel; modification of levees around West Sacramento; and removal of flow constrictions from the Yolo Bypass. Within each alternative, several options were developed to satisfy the planning objectives. The no action alternative is included as the baseline condition. The following is a description of each alternative.

No Action

For the no action alternative, there would be no Federal participation in flood control alternatives for increased levels of flood protection. Also, the same assumptions used for the without project condition described previously would be applied to the no action alternative.

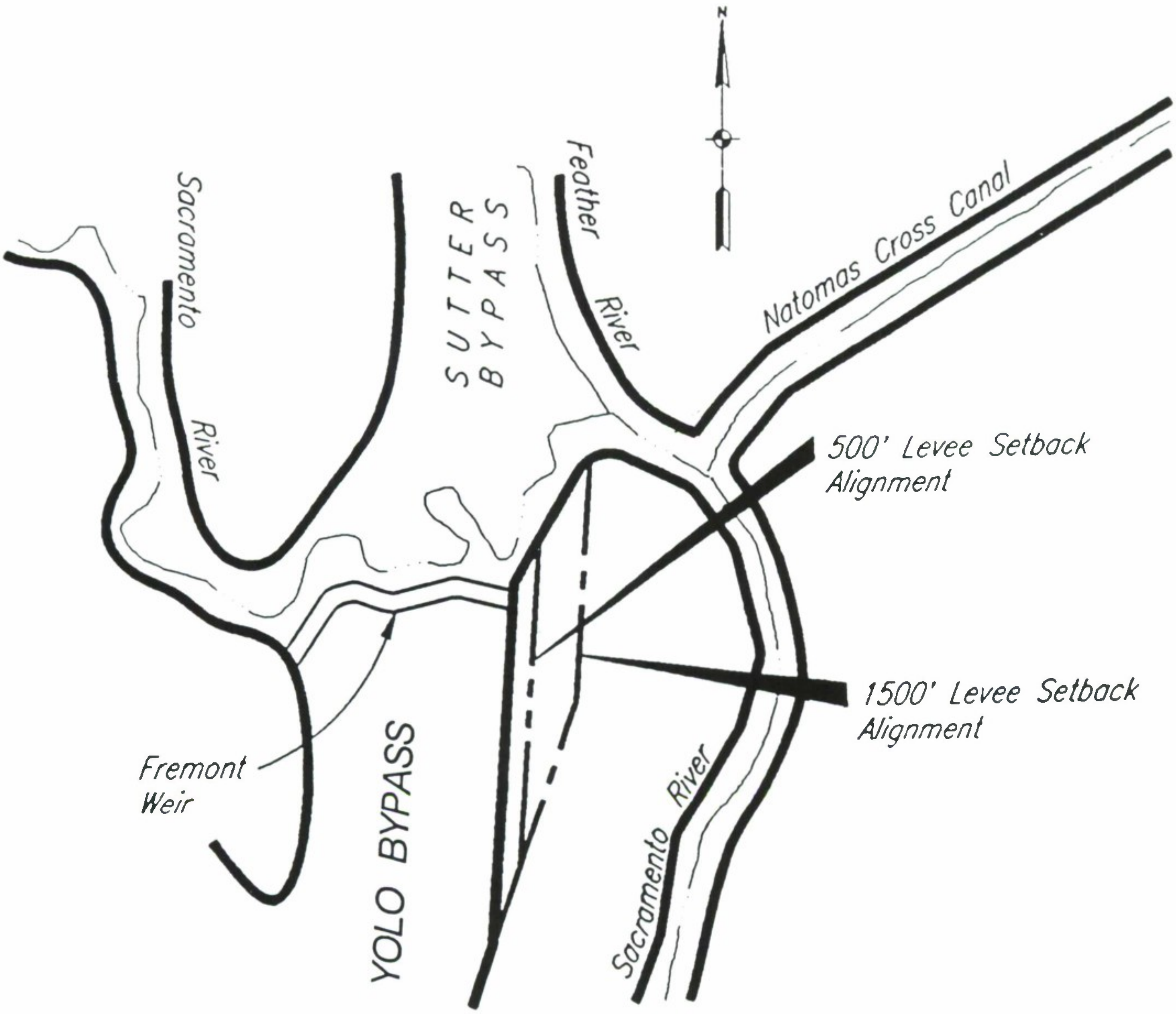
Modify Fremont Weir and Yolo Bypass

The following alternative options focus on facilitating or improving the conveyance of the Fremont Weir and the Yolo Bypass, thereby diverting greater flows into the Yolo Bypass.

Option 1. - Remove the deposited material both upstream and downstream of the Fremont Weir to an elevation less than or equal to the weir crest elevation of 30.4 feet. The DWR has recently (1986 and 1987) undertaken efforts to lower the elevation of sediment upstream and downstream of the Fremont Weir to an elevation of 27 to 28 feet. A portion of this work on the east side of the bypass (approximately 375 acres) has not been completed. For this alternative, approximately 200,000 cy of additional material would be removed to ensure that land surface elevations are generally no higher than 30.4 feet. Material would either be deposited on nearby land as fill or used to improve existing levees on the Yolo Bypass or Sacramento River.

Option 2. - Widen the Fremont Weir and the Yolo Bypass at Fremont Weir by 500 or 1,500 feet. The east levee of the Yolo Bypass would be set back in order to better align the inlet to the Yolo Bypass with the outlet of the Sutter Bypass. The length of levee to be set back (in a landward direction) is approximately 18,400 linear feet for the 500-foot option and 21,600 linear feet for the 1,500-foot option. Alignment of the proposed setbacks are shown in Figure 33. The weir would be extended 500 or 1,500 feet and would be constructed to match the current design. This option also considered the modification of about 400 feet of embankment material along the Fremont Weir at its junction with the Old River. The embankment material would be replaced with a concrete weir and riprap to match the current design.

Option 3. - Lower the crest elevation of the Fremont Weir by 0.5 or 1.0 foot. This would involve lowering and reshaping approximately 9,120 linear feet of concrete weir. To ensure proper functioning of the weir at these elevations, additional sediment removal would be necessary to lower the land surface to an elevation equal to or less than the weir crest elevations. Approximately 400,000 and 600,000 cy of material would need to be removed and disposed of when lowering the weir by 0.5 and 1.0 foot, respectively. Again, the area of sediment removal (approximately 375 acres) would be confined to the east side of the bypass that has not been modified by the DWR. (Not all of the area within the 375 acres would be impacted by construction activities because of irregularities in the ground surface elevations.)



SACRAMENTO METROPOLITAN AREA
CALIFORNIA

MODIFY FREMONT WEIR AND YOLO BYPASS

NOT TO SCALE

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
JANUARY 1989

FIGURE 33

Modify Sacramento Weir and Bypass

Several options to modify the Sacramento Weir and/or its operation in order to divert additional floodwaters into the Yolo Bypass were considered. The Sacramento Weir consists of 48 bays (gates) that are manually operated. To adjust the flow that passes over the weir, the bays are opened individually as specified in the operating criteria. Each bay consists of 36, 3 by 12-inch wooden planks that are approximately 6 feet long. The effective overflow weir crest elevation is 21.5 feet. Traffic from Highway 16 and the UPRR would need to be rerouted or diverted during any construction involving the weir.

Option 1. - Remove the existing gate structures and form a smooth concrete surface along the weir with a crest elevation of 21.2 feet. The length of weir to be modified is approximately 1,824 feet.

Option 2. - Widen the Sacramento Weir and set back the north levee of the Sacramento Bypass by 500 or 1,500 feet in a landward direction. The north levee (approximately 9,500 feet) was selected because land north of the bypass is relatively undeveloped. Alignment of the proposed setbacks is shown in Figure 34. The design of the weir extension would match that of the current design. Operation of the gates would remain the same as the existing operation.

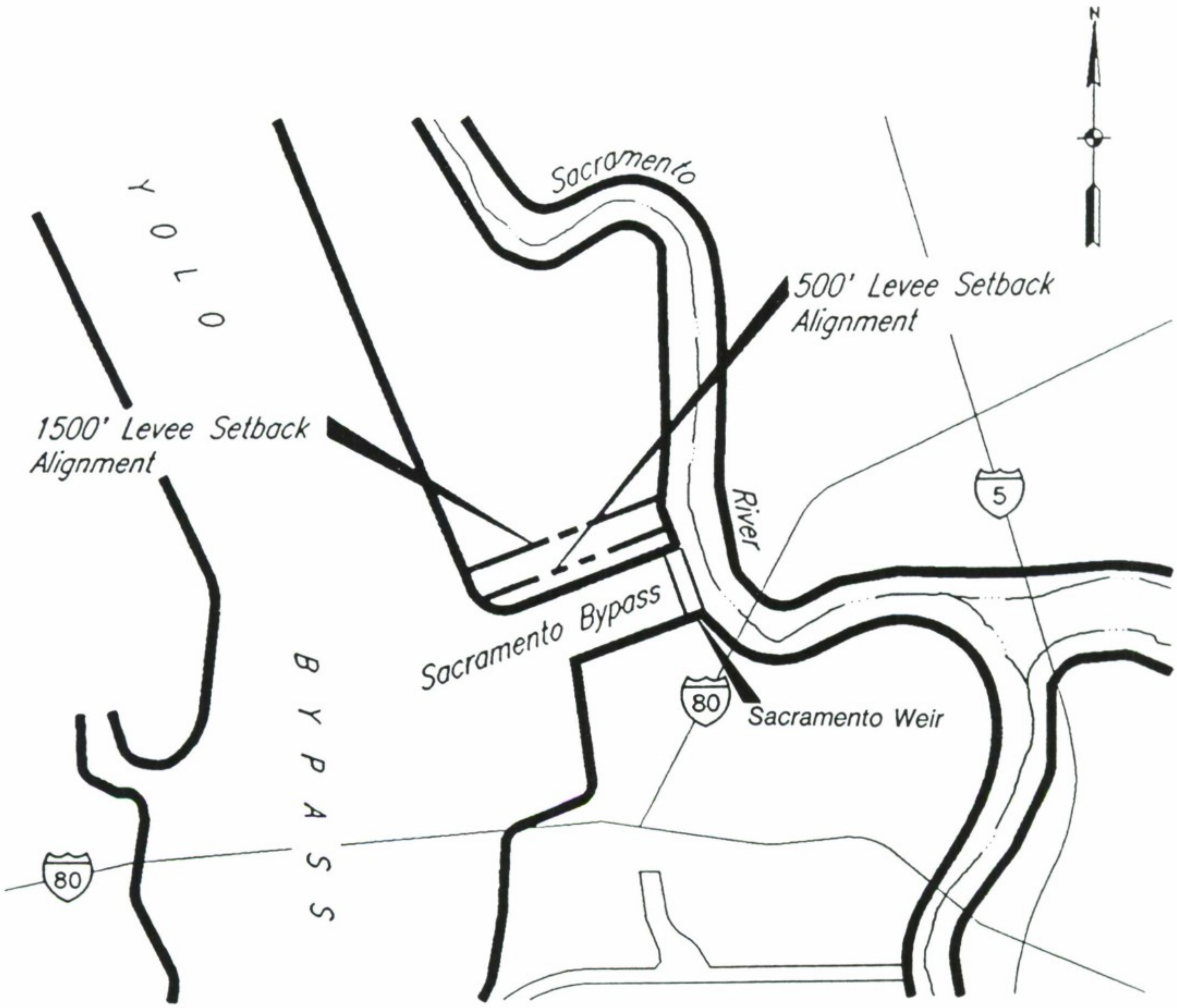
Option 3. - Lower the weir crest by either 0.5 of 1.0 foot while retaining the same gate configuration by extending the boards to their original elevation.

Divert Floodwaters into the Sacramento River Deep Water Ship Channel

This alternative involves the diversion of a portion of the floodwaters (between 20,000 and 40,000 cfs) in the Yolo Bypass and/or the Sacramento River into the Ship Channel (Figure 35). This would be done by using pumps and diversion facilities that connect the Sacramento River and Yolo Bypass to the Ship Channel near the Port. This alternative would also require the relocation of Port facilities and new levees on both sides of the Ship Channel adjacent to the Port.

Modify Levees Around West Sacramento

This alternative consists of raising portions of the levees around the city of West Sacramento to increase the level of flood protection to that area. Both 100-year and 200-year levels of flood protection were analyzed (Figures 36 and 37). Approximately 91,000 linear feet of levee would need to be raised for the 100-year level of protection and 118,000 linear feet for the 200-year level of protection. Design levee crown elevations were based on existing levee crown elevations, 100- and 200-year water surface profiles, and design freeboard criteria. Proposed levee raising on the west side of the Yolo Bypass and north side of the Sacramento Bypass would be included as potential mitigation for adverse flood impacts due to levee raising around West Sacramento. All raising and widening would be landward.



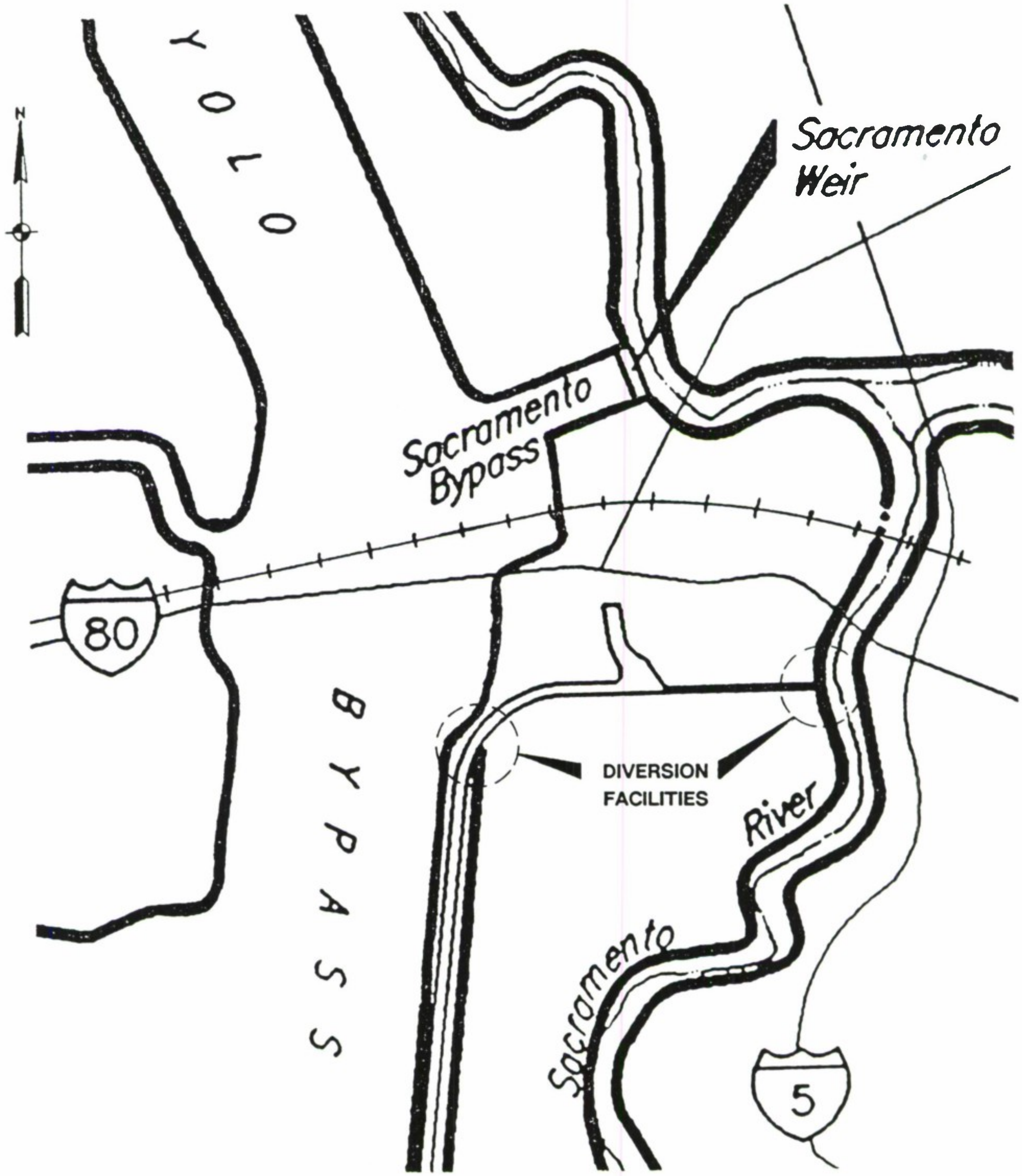
SACRAMENTO METROPOLITAN AREA
CALIFORNIA

MODIFY SACRAMENTO WEIR AND BYPASS

NOT TO SCALE

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
JANUARY 1989

FIGURE 34



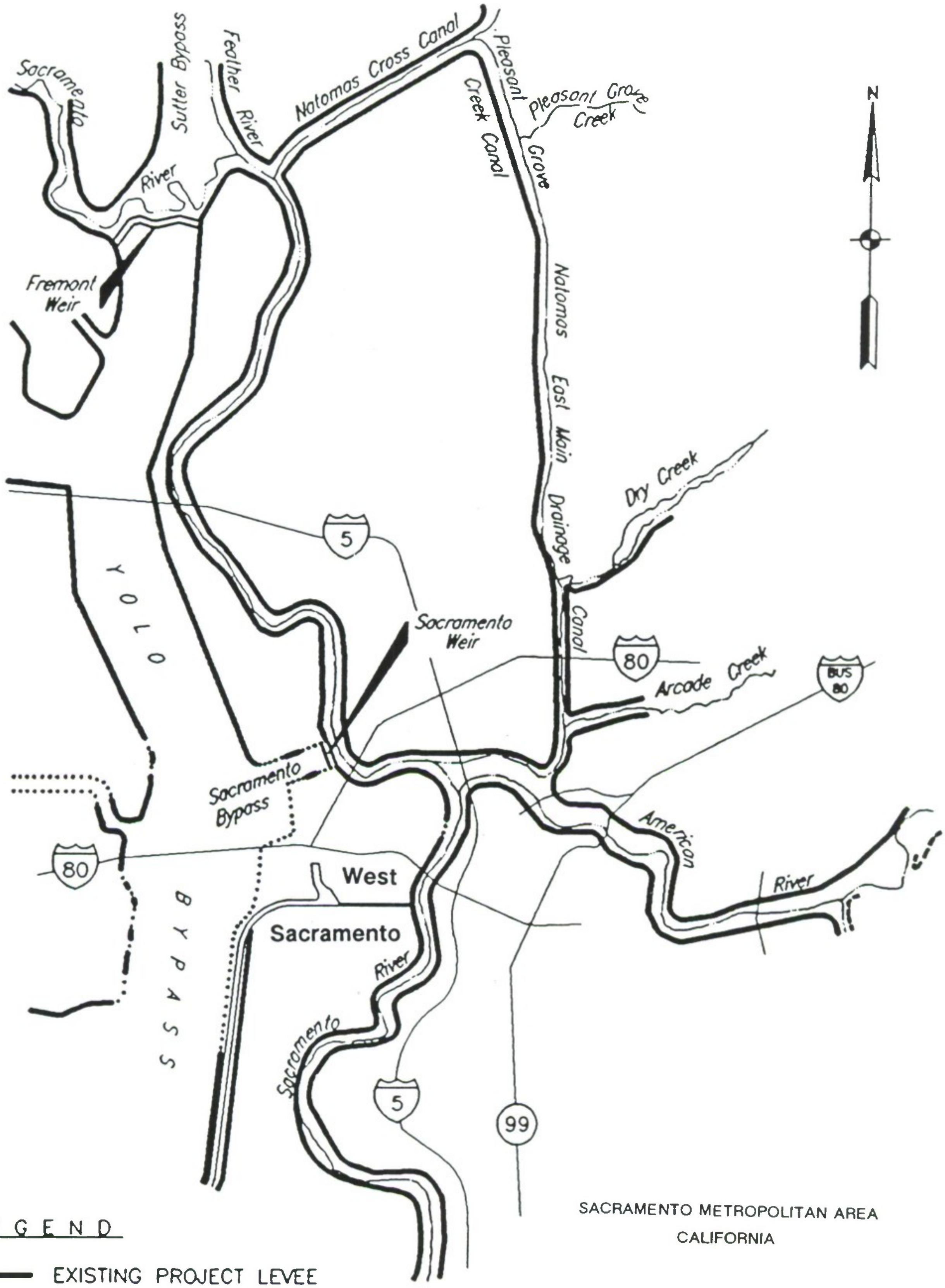
SACRAMENTO METROPOLITAN AREA
CALIFORNIA

DIVERT FLOODWATERS INTO THE SACRAMENTO RIVER DEEP WATER SHIP CHANNEL

NOT TO SCALE

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
JANUARY 1989

FIGURE 35



LEGEND

EXISTING PROJECT LEVEE

EXISTING PROJECT LEVEE TO BE RAISED FOR 100 YR. PROTECTION (91,000 L.F.)

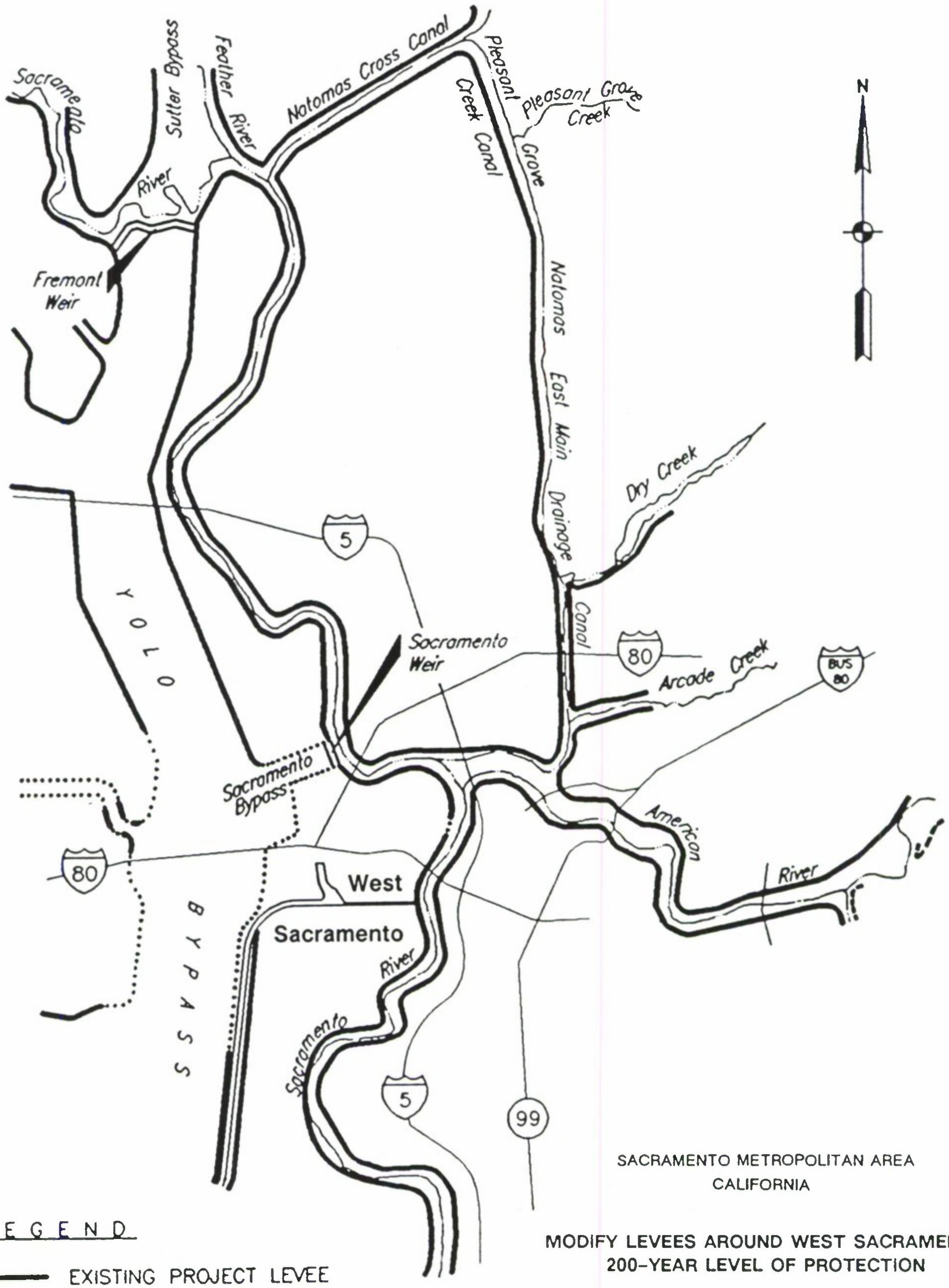
NOT TO SCALE

SACRAMENTO METROPOLITAN AREA
CALIFORNIA

MODIFY LEVEES AROUND WEST SACRAMENTO
100-YEAR LEVEL OF PROTECTION

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
JANUARY 1989

FIGURE 36



SACRAMENTO METROPOLITAN AREA
CALIFORNIA

MODIFY LEVEES AROUND WEST SACRAMENTO
200-YEAR LEVEL OF PROTECTION

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
JANUARY 1989

FIGURE 37

LEGEND

EXISTING PROJECT LEVEE

EXISTING PROJECT LEVEE TO BE RAISED FOR 200 YR. PROTECTION (118,000 L.F.)

NOT TO SCALE

Remove Flow Constrictions from Yolo Bypass

This alternative consists of replacing highway and railroad embankments with bridge structures to improve flow conveyance and reduce flood stages in the area of the Yolo Bypass adjacent to West Sacramento (Figure 38). This would involve replacement of approximately 4,700 linear feet of embankment material from I-80 and 9,700 linear feet from SPRR. Work on both the I-80 and SPRR crossings would be accomplished by constructing a new permanent pile-supported section parallel and adjacent to the existing embankment portion, followed by removal of the existing embankment section. An alternative measure for the I-80 embankment sections is to place 96-inch-diameter concrete pipes spaced 12 feet on center through the embankment sections.

Combination

Any of the alternatives and options described above could be combined to develop a flood control plan for the study area. Each alternative (and option) will be evaluated individually to determine whether or not that alternative is economically feasible. Depending on the local sponsors interest and Federal criteria, those alternatives that are potentially feasible could be considered individually and in combination in the feasibility phase of the investigation.

COMPARISON OF ALTERNATIVE PLANS

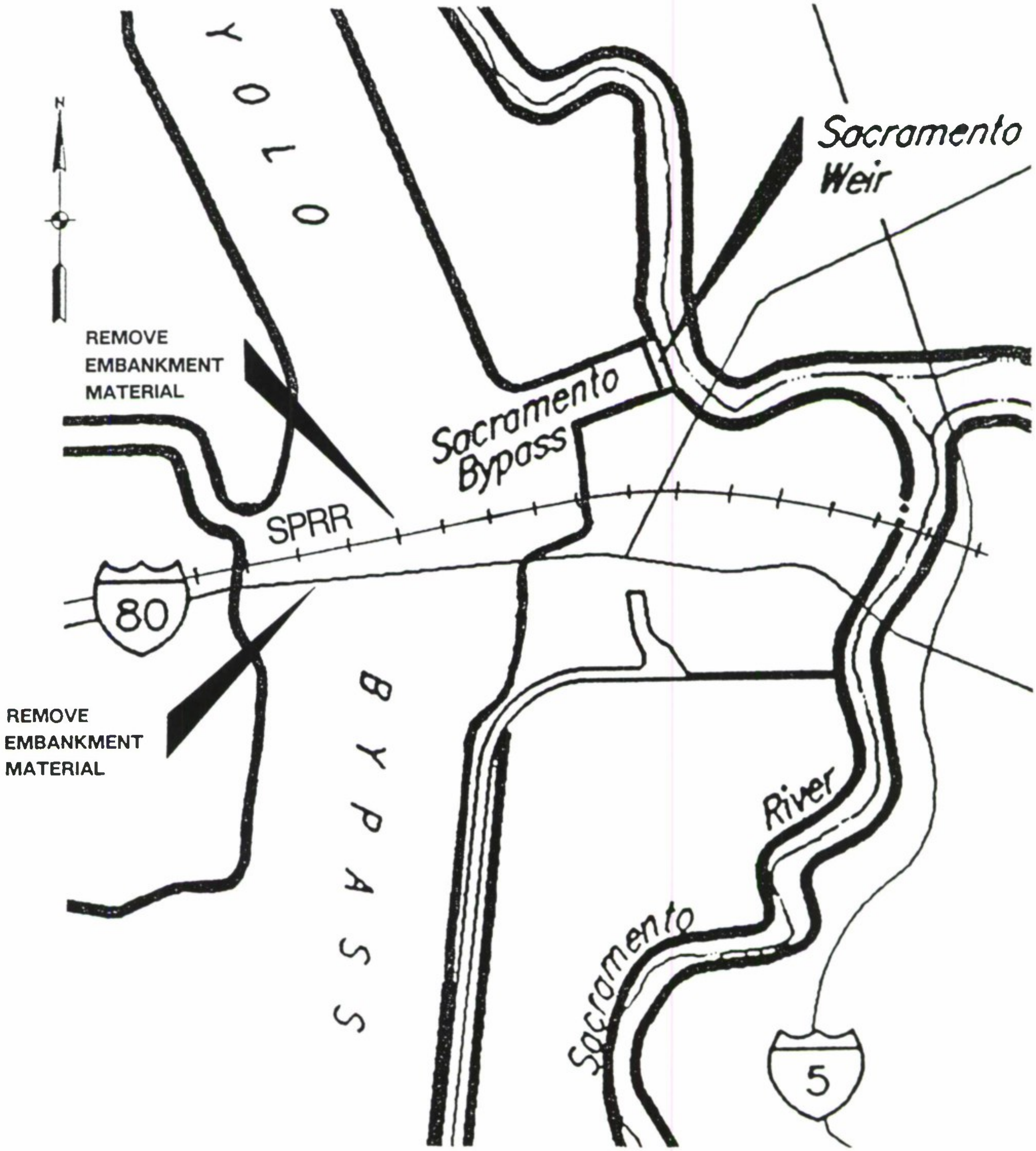
No Action

With the no action alternative, the threat of future flooding, flood damages and loss of life would continue to exist. The estimated damages in West Sacramento from the 100-year and 200-year flood events are $850 million and $1.2 billion, respectively. Flood damages in Area C from the 100-year and 200-year flood events are $16 million and $17 million, respectively. For South Sacramento, including the Greenhaven area, there is 200-year level of flood protection from the Sacramento River side, assuming the existing levees are repaired for structural deficiencies.

Hydrologic Evaluation of Alternatives

In order to compare the hydrologic and hydraulic impacts of each alternative, an unsteady flow model (DWOPER, dynamic wave operational model) was developed. The model was calibrated using hydrologic and hydraulic data from the 1983 and 1986 flood events and provides flow rates and water surface elevations at particular locations in the study area over the time interval considered. The model reasonably simulated the peak flows and peak water surface elevations of the 1983 and 1986 flood events, but model results are considered of a reconnaissance level. The model will be refined in more detail in the feasibility phase of the investigation.

Because the model was calibrated on the 1983 and 1986 flood events, modifications were necessary to incorporate the physical changes that have occurred in and adjacent to the study area since February 1986. (These physical changes have been discussed in Chapter IV, Technical Studies.) With these modifications, the model generally represents physical conditions as of September 1988 and the without project condition for the comparison of flood



SACRAMENTO METROPOLITAN AREA
CALIFORNIA

REMOVE FLOW CONSTRICTIONS FROM YOLO BYPASS

NOT TO SCALE

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
JANUARY 1989

FIGURE 38

control alternatives. (Some of the levee embankment modifications and sediment removal programs being considered by local entities for implementation in the future could modify the model simulations for the without project condition.)

For the with project condition, various physical parameters were modified in the existing model to simulate the various flood control alternatives. A comparison of model results under with and without project conditions was based primarily on differences in peak water surface elevations and flows within the study area.

Modify Fremont Weir and Yolo Bypass. - Hydrologic and hydraulic modeling efforts indicate that removal of deposited material upstream and downstream of the weir is effective in reducing flood stages in the Sacramento River between the confluence with the Feather River and the Sacramento Bypass. (Although the Natomas Cross Canal is not included in the study area, it should be noted that reducing the flood stages in the Sacramento River would also reduce the flood stages in the Natomas Cross Canal.) Flood stages for the expected 100-year flood event or an event similar to the 1986 flood event could be reduced between 0.1 and 0.5 foot in this river reach, depending on location, if the land surface both upstream and downstream of the weir is reduced and maintained at 30.4 feet. In addition, flood stages would be reduced by similar amounts in the Yolo Bypass in the immediate vicinity of the weir. Impacts to flood stages throughout the remainder of the study area are minimal and suggest that the system tends to revert to existing conditions (without project conditions) at and downstream of the Sacramento Bypass.

Widening the weir and the Yolo Bypass at the Fremont Weir up to 500 feet does not have a significant impact on flood stages in the study area. Widening to 1,500 feet does have an impact on flood stages in the Sacramento River between the confluence with the Feather River and the Sacramento Bypass. For the 100-year flood event, flood stages in this river reach would be reduced between 0.1 and 0.5 foot, depending on location. Impacts to flood stages throughout the remainder of the study area are minimal.

Lowering the existing weir crest about 1.0 foot and maintaining the land surface elevation both upstream and downstream of the weir at 29.4 feet by removing material can also reduce flood stages in the Sacramento River between the Feather River and the Sacramento Bypass. With this plan, the observed 1986 water surface elevation of the Sacramento River near Verona would be reduced about 1.5 feet. Small increases in water surface elevation would result in the Yolo Bypass.

In general, the hydrologic and hydraulic modeling efforts indicate that the proposed modifications to the Fremont Weir and the Yolo Bypass (near the weir) would reduce flood stages significantly for major flood events in the Sacramento River between the Feather River and the Sacramento Bypass, in the Yolo Bypass near the weir, and in the Natomas Cross Canal. Flood stages throughout the remainder of the study area would not change significantly because (1) the maximum additional flow expected over the Fremont Weir for a 100-year flood event is about 20,000 cfs and (2) the flow system tends to revert to the without project condition at and downstream of the Sacramento Bypass. (An additional 20,000 cfs in the Yolo Bypass downstream of the Fremont Weir is equivalent to about 0.2 to 0.3 foot during major flood events.)

Modify Sacramento Weir and Bypass. - Removing the existing gates and forming a smooth concrete surface with a crest elevation of 21.2 feet would only have a minimal impact on peak flood stages for events similar to or larger than the February 1986 flood in the study area. As noted in Chapter IV, Technical Studies, "Sacramento River at Verona," floodwaters would begin to move over the Fremont Weir when the flow in the Sacramento River at Verona is about 58,000 cfs. Without gates at the Sacramento Weir, floodwaters would also begin to move over this weir at a flow of about 58,000 cfs in the Sacramento River. (Water surface elevations in the Sacramento River at the Sacramento Weir are influenced by backwater conditions from the American River, tides, and other factors.) Because of this, removing the gates would not significantly change the duration of flooding within the Yolo Bypass, but would change the flow regime during the time period that floodwaters are present in the bypass.

Widening the weir and bypass and maintaining the existing gate operation would increase the peak flows over the weir and would reduce the peak flood stages in the Sacramento River downstream of the weir for major floods similar to or larger than the February 1986 flood event. Widening the weir and bypass by 500 feet and 1,500 feet would increase peak flows over the weir by 10,000 cfs and 20,000 cfs, respectively, for the 100-year flood event. Flood stages for the 100-year flood event in the Sacramento River downstream of the weir could be reduced by about 1.5 feet, depending on the distance from the weir. Increases in flood stages in the Yolo Bypass are insignificant because 10,000 cfs to 20,000 cfs represents only a 0.1- to 0.2-foot change in water surface elevation for flood events equal to or greater than the 100-year flood event.

Lowering the weir crest and maintaining the same gate operation would have results similar to widening the weir and bypass. When the weir crest is lowered, the gate structures would have to be increased in height the same amount in order to maintain the same operation. Lowering the weir crest by 0.5 and 1.0 foot would increase peak flows over the weir by 5,000 cfs and 10,000 cfs, respectively, for the expected 100-year flood event.

Divert Floodwaters into the Sacramento River Deep Water Ship Channel. - Based on information in Chapter IV, Technical Studies, "Sacramento River Deep Water Ship Channel," the 100- and 200-year flood events in the Sacramento River system would probably result in flood stages of 16.0 feet and 16.4 feet, respectively, in the Ship Channel near the Port. A rating curve developed for the Ship Channel downstream of the Port indicates that a 1.0-foot increase in the water surface elevation at the Port for the 100-year or 200-year flood event would result in a hydraulic gradient sufficient to convey about 10,000 cfs downstream through the Ship Channel. Similarily, 2.0- and 4.0-foot increases in the water surface elevation at the Port would result in the conveyance of about 20,000 cfs and 35,000 cfs, respectively.

Average velocities in the Ship Channel for a flow of 70,000 cfs would be 3 to 4 fps although localized velocities might be as high as 10 fps. For a flow of 40,000 cfs, average velocities would be 2 to 3 fps. Localized scour of the channel banks would occur during periods of peak flow although sediment deposition would dominate throughout the length of the Ship Channel for the duration in which floodwaters are diverted from the Sacramento River and/or Yolo Bypass.

Modeling efforts indicated that significant reductions in flood stages for major flood events similar to the 1986 flood event or larger could be achieved in the Sacramento River downstream of the American River by diverting excess floodwaters from the Sacramento River into the barge canal at the location of the lock. Diversions considered ranged between 20,000 cfs and 40,000 cfs. Diverting similar flows into the Ship Channel from the Yolo Bypass only had a minimal impact on flood stages in the study area for major flood events.

Modify Levees Around West Sacramento. - Based on Table 10, the estimated level of flood protection for the city of West Sacramento is about a 90-year flood event. Actual levee failures may occur at higher or lower recurrence intervals (flood stages) depending on flood duration, wave action, bank erosion, emergency efforts, etc. The 90-year level of flood protection assumes that the levee embankments are structurally stable and that any necessary structural repairs recommended under the "Sacramento River Flood Control System Evaluation," Corps of Engineers, May 1988, will be implemented prior to any improvements considered in this study.

Raising and widening levee embankments around West Sacramento to provide design levels of flood protection for the 100-year, 200-year and larger flood events would reduce the probability of levee failure and overtopping. This reduction would have an adverse impact on flood stages at and downstream of those locations. As indicated in Chapter IV, Technical Studies, "Flooded Areas," a single levee breach on the Yolo Bypass side of West Sacramento could potentially occur during a 100-year flood event. Preventing this levee breach during the 100-year flood event would increase flood stages in the Yolo Bypass downstream of this location up to about 0.3 foot. For a 200-year flood event under existing conditions, more than one levee breach is probable, and preventing this occurrence could increase downstream flood stages up to about 0.5 foot.

Remove Flow Constrictions from Yolo Bypass. - Hydrologic and hydraulic models indicate that replacement of embankment material with bridge structures at both I-80 and the SPRR can reduce flood stages in the Yolo Bypass and the Sacramento Bypass adjacent to West Sacramento. For a major flood event, removal of the embankment material could reduce flood stages in the Yolo and Sacramento Bypasses upstream of I-80 and adjacent to West Sacramento between 0.5 and 1.0 foot. Reductions in flood stages in the Sacramento River and in the Yolo Bypass above Woodland are relatively insignificant.

No downstream adverse flood impacts are associated with removal of the embankment material. Because of the increased flow area possible at both I-80 and the SPRR, peak flow velocities and scour potential would also be reduced in the vicinity of the bridge structures.

Environmental Effects

Costs of potential mitigation measures were based on similar mitigation plans developed for projects and other studies in or adjacent to the Sacramento River watershed. Costs are considered as reconnaissance level and have been developed to estimate the total costs of various alternatives. For several alternatives, environmental costs are significant and impact the economic viability of the potential flood control alternatives.

Modify Fremont Weir and Yolo Bypass. - Flood control alternatives that include widening the Yolo Bypass near the Fremont Weir (by moving about 3 to 4 miles of the east levee embankment located just downstream of the weir either 500 or 1,500 feet back) would cause significant impacts to riparian vegetation. An adjacent irrigation canal (Tule Canal) parallels this section of the levee embankment on the waterward side of Yolo Bypass, and this canal supports significant areas of riparian vegetation and marsh habitat.

Removing this section of the existing levee embankment and hauling the material to the proposed alignment would be accomplished from the land side of the levee and would minimize any work in or immediately adjacent to the canal. Assurances from local landowners and the local sponsor would be required to prevent filling in and moving the existing canal toward the new alignment in the future to minimize adverse environmental impacts. Even with these conditions, about 60 acres of riparian vegetation, including emergent marsh, riparian forest and riparian scrub, could still be disturbed.

Based on cost estimates from "Wildcat and San Pablo Creeks," U.S. Army Corps of Engineers, August 1988, the cost to replace similar habitat values is estimated to be $18,000 per acre. This would include planting near the canal and maintaining the plantings for three seasons. The total cost of this mitigation plan is estimated at $1 million.

Lowering the existing weir crest by 1.0 foot could increase the duration of floodflows in the Yolo Bypass by 1 to 4 days per flood event. Increased flow durations could cause damage to oak trees in the bypass, but the magnitude of the change is so small that the effects are probably minor.

Sediment removal that would be required in conjunction with this alternative would impact up to 200 acres of land area just upstream and downstream of the weir. Sediment removal plans would be similar to work recently accomplished by the State. Selective clearing of this area would be accomplished by avoiding areas of mature riparian vegetation. This would limit impacts to riparian scrub/shrub. The current estimate to revegetate this area based on the State's program is about $450 per acre for seeding. Total cost of this mitigation alternative is $100,000, which includes the cost of an airplane equipped to seed from the air.

Increasing the volume of water that passes over the Fremont Weir would increase the number of fish carried into the Yolo Bypass at this location. This impact could be offset by reductions in the volume of water passing through the Sacramento Bypass due to implementation of this alternative. Whether or not this alternative would result in additional fish being stranded in the Yolo Bypass as floodwaters recede is not known, but studies during the feasibility phase could address this possibility. Since there is insufficient information to determine if an adverse condition would result, no mitigation costs have been included in this evaluation. If adverse impacts are identified, potential mitigation measures could include increasing the number of fish released by hatcheries in the Sacramento River or enhancing spawning and rearing habitats along the river.

Direct construction impacts to aquatic resources could result from land surface depressions created by construction activities. Mitigation would require construction areas graded with a slope towards the Tule Canal.

Modify Sacramento Weir and Bypass. - Flood control alternatives that consider widening the Sacramento Bypass and the Sacramento Weir would damage riparian vegetation because of construction activities. Because of significant development on the landward side of the south levee of the Sacramento Bypass, widening alternatives considered setting back the north levee (and extending the weir to the north).

An irrigation canal is adjacent and parallel to a portion of the north levee on the waterward side of the Sacramento Bypass. Removing the existing north levee embankment and hauling the material to the proposed alignment would be accomplished from the land side of the levee and would minimize any work in or immediately adjacent to the canal. In addition, the weir would be extended to the new levee alignment. Even with the above conditions, about 2 acres of riparian forest would be impacted. Required mitigation would include revegetation of about 3 acres, at a total cost of about $60,000.

Removing the existing gates and forming a smooth concrete surface with a crest elevation at 21.2 feet (no widening) would not significantly change the duration of flooding within the Yolo and Sacramento Bypasses, but would change the flow regime during the time period that floodwaters are present in the bypasses. Environmental impacts to vegetation from this option are considered minor.

Lowering the weir crest by 0.5 foot and 1.0 foot (no widening) and maintaining the existing gate operation would increase the duration and volume of floodwater diverted through the Sacramento Bypass. Sediment removal either upstream or downstream of the weir is not proposed with this option. If sediment removal is needed, riparian vegetation in the toe drains waterward of the bypass levees could be avoided to minimize impacts.

Widening the weir and bypass would increase the volume of floodwaters diverted into the Sacramento Bypass. Lowering the weir crest would not only increase the volume of floodwater diverted into the bypass but would also increase the duration in which floodwaters are diverted. The increase in volume and/or duration of floodwaters diverted into the bypass system would probably result in additional fish being stranded in the Yolo Bypass as floodwaters recede. The magnitude of this impact has not been estimated but could be evaluated in the feasibility phase of the investigation. Although potential costs have not been determined, mitigation alternatives could include increasing the number of fish released by hatcheries in the Sacramento and American Rivers or enhancing spawning and rearing habitats along the river. Environmental costs associated with this potential adverse impact will be considered when the total cost of modifying the Sacramento Weir and Sacramento Bypass is estimated.

Direct construction impacts to fish under this alternative could result from land surface depressions created by construction activities. Mitigation would require construction areas graded with a slope towards the Tule Canal.

Divert Floodwaters into the Sacramento River Deep Water Ship Channel. - Terrestrial impacts of this alternative would be minor. Construction of new levees and associated relocations of existing facilities around the Port would

require reseeding of levee embankments and other construction areas for erosion control.

Water would be diverted through the Ship Channel in one of two methods: by using a siphon with a pump or by constructing overflow weirs. Fisheries impacts associated with these methods would be minimal. Diverting water through a siphon would require a pump to initiate the flow. The gravity flow of the siphon would divert water without the continuous use of pumps. Any impact would be limited to the initial action to begin the flows. The use of overflow weirs to divert floodwaters would also have a minimal impact on fisheries.

Modify Levees Around West Sacramento. - Levee embankment modifications required in this alternative would be accomplished by raising and widening levee sections to the landward side only. In addition, construction activities would be limited primarily to the top and the landward side of the existing levee embankment.

Levee embankment modifications would be required on the Sacramento River, Sacramento Bypass and both sides of the Yolo Bypass west of the city of West Sacramento. Construction activities could impact between 10 and 15 acres of riparian forest and emergent marsh, depending on the design level of flood protection. Costs of potential mitigation alternatives, primarily revegetation, range between $100,000 and $150,000. No work is considered necessary for the cross levee at the southern boundary of West Sacramento.

Remove Flow Constrictions from Yolo Bypass. - Construction and clearing activities involved in removing all of the embankment material (replacing with bridge or culvert structures) from I-80 and the SPRR on the Yolo Bypass would impact about 25 acres of riparian scrub. Environmental impacts associated with localized decreases in flood stages and peak velocities are considered insignificant.

The estimated cost to mitigate for the loss of riparian scrub is $200,000. Mitigation measures could include revegetation of constructed and cleared areas and revegetation of other nearby land areas that could be acquired in fee or easement.

Construction Costs

Reconnaissance level construction cost estimates for the flood control alternatives are discussed in this section. First costs are based on October 1988 price levels. Annual costs are based on an 8-5/8 percent interest rate and a 50-year amortization period. The annual cost of operation and maintenance is included in the estimated annual costs. All costs assume that the levee embankments of the Sacramento River Flood Control Project system are structurally stable at the existing design water surface elevation.

Modify Fremont Weir and Yolo Bypass. - This alternative involves various modifications to Fremont Weir and its existing operation. Each option would increase the peak flow and divert more water over the weir than under the without plan condition. The annual cost of each option includes a cost of $65,000 for monitoring sediment deposition near the weir, removing and disposing future deposited material, and acquiring land necessary for disposal

of material. The monitoring program consists of setting up transect lines perpendicular to the weir, spaced approximately 1,000 feet apart, and surveying ground elevations in the summer months during those years in which the floodwaters reached the weir.

Assurances would be required from local interests to maintain the existing flow conveyance within the Sacramento River channel downstream of Fremont Weir. Although this channel reach was degrading under prior conditions (see Figure 26), a monitoring and maintenance program would still be required to ensure that channel aggradation, if it does occur, would not adversely impact design levels of flood protection for the alternatives.

Sediment removal in conjunction with the flood control alternatives would require the acquisition of about 100 to 200 acres of land outside, but adjacent to the Yolo Bypass, for disposal. If purchased in fee, the land costs would be about $400,000. This cost could be less if excavated material is used to enlarge adjacent levee embankments, thereby minimizing land acquisition requirements.

Since the February 1986 flood event, the State of California has removed soil material just upstream and just downstream of the weir. In 1986, the State removed about 500,000 cy of sediments from the west side of the weir and disposed of the material outside of Yolo Bypass at a cost of about $650,000. (A local landowner permitted disposal of material on his property without the added cost of land acquisition.) In 1987, the State removed about 800,000 cy of sediments adjacent to the middle section of the weir at a cost of about $1 million. This material was disposed of at a central location in the Yolo Bypass just downstream of the weir. (The disposal material was stacked to minimize flow obstruction.) The State has plans to remove an additional 650,000 cy of material from the east side of the bypass adjacent to the weir in the future, but the work depends on funding. In 1988 and 1989, State funding was not available. The material removed from this area of the weir could be disposed of by enlarging sections of the levee embankment on both the east levee of the Yolo Bypass and the west levee of the Sacramento River near the weir. To date, the State's sediment removal program has involved the removal of material down to an elevation about 1 to 2 feet lower than the crest elevation of the weir as shown in Figure 19. Localized areas of sediment aggradation near the trees were not excavated.

For planning purposes, it is unlikely that additional material will be removed by the State because funds have not been approved for that purpose. In addition, since the weir was generally functioning as designed during the February 1986 flood event and prior to any sediment removal, future sediment removal by the State is not considered necessary maintenance to ensure the weir operation. As a result, the cost to remove additional material is being evaluated as a potential alternative under this investigation.

Based on the sediment removal work performed by the State to date, about 200,000 cy of additional material would need to be removed to ensure that land surface elevations both upstream and downstream of the weir are generally no higher than the existing weir crest elevation of 30.4 feet. The estimated cost of sediment removal is about $250,000.

In addition, 35 existing flowage easements in the Sacramento and Yolo Bypasses were reviewed. Of these easements, none have limits on the depth or

duration of flooding. Assuming these 35 easements are representative of all flowage easements in the Sacramento and Yolo Bypasses, increased depth and duration of flooding would not require modifications to existing easements or additional compensation to landowners. (The bulk of the existing flowage easements provide for "a perpetual right and easement, without recourse to compensation for damage therefrom, past, present or future, for the passage of all waters of the Yolo Bypass which may from time to time inundate or which has heretofore inundated the lands of the grantors over, upon and across all of the following described lands....").

No project levee exists on the west side of the Yolo Bypass downstream of the confluence with Putah Creek. In this area, flowage easements were obtained to the outer limits of flooding under design flow conditions (at the design water surface elevation). If peak flow conditions in this area were increased over design conditions, then additional flowage easements would be required because the extent of flooding would be increased. The need for additional flowage easements in the Yolo Bypass south of Putah Creek would be addressed in more detail in the feasibility phase of the study.

As discussed in the section on the "Hydrologic Evaluation, Comparison of Alternative Plans," proposed modifications to the Fremont Weir and the Yolo Bypass (near the weir) would not have a significant impact on flood stages in the study area downstream of the Sacramento Bypass. As a result, no additional flowage easements are required in the Yolo Bypass area south of Putah Creek.

Widening the weir either 500 or 1,500 feet involves setting back the east levee of the Yolo Bypass to increase the flow capacity of the bypass. The east levee was selected because this would allow better alignment with the inlet of the Yolo Bypass with the outlet of the Sutter Bypass. The length of setback levee would be approximately 3 miles (see Figure 33). This alternative also includes extending the weir either 500 or 1,500 feet. The design of the weir extension would be the same as the current design.

Based on the evaluation of existing flowage easements and peak flood stages downstream of Putah Creek, no additional flowage easements or compensation would be needed for lands within the Sacramento and Yolo Bypasses for the options described. There is a concern that increased flows and durations will adversely affect local drainage within the various tributaries (Knights Landing Ridge Cut, Willow Slough, etc.) to the Yolo Bypass. This concern will be addressed in more detail in the feasibility phase of the study.

Construction costs for the various options are summarized below:

Option		First Cost($)	Annual Cost($) 1/
1		650,000	120,000
2			
	500 ft	9,000,000	840,000
	1,500 ft	13,400,000	1,220,000
3			
	0.5 ft	1,470,000	190,000
	1.0 ft	2,035,000	240,000

1/ Annual cost includes a cost of $65,000 for monitoring sediment deposition near the weir and removing and disposing of future deposited material.

Modify Sacramento Weir and Bypass. - This alternative includes various modifications to the Sacramento Weir and its existing operation. Most of the options would increase the peak flow and divert more water over the weir than under the without project condition.

Removing the existing gates and forming a smooth concrete surface with a crest elevation of 21.2 feet has only a minimal impact on peak flood stages similar to or larger than the February 1986 flood event in the study area. (See section on "Hydrologic Evaluation, Comparison of Alternative Plans.") During the 100-year (and greater) flood event, all 48 gates would be open during the rising limb of the flood hydrograph. In addition, all gates would be open for 3 or more days until peak flood stages are attained in the study area. Because of the operation time when all gates are open, peak flood stages attained with this alternative (no gates) would be similar to peak flood stages with the existing system. Since peak flood stages with or without this alternative are similar, no additional flowage easements are required for the Yolo Bypass. (See the discussion in the section "Modify Fremont Weir and Yolo Bypass, Construction Costs.") The first cost and annual costs for this alternative are $85,000 and $10,000, respectively. (Because peak flood stages attained in the study area with or without the gates are similar, no reduction in flood damages has been attributed to this option. It is possible, however, that a permanent structure without gates would reduce the possibility of operational problems given the labor-intensive requirements of manually opening each of the 48 gates.)

Widening the weir and bypass and maintaining the existing gate operation would increase the peak flows over the weir for major flood events similar to or larger than the February 1986 flood event. Increases in peak flows would increase flood stages in the Yolo Bypass downstream of the Sacramento Bypass by 0.1 to 0.2 foot for flood events equal to or greater than the 100-year flood event. The higher stages would require additional flowage easements in the Yolo Bypass downstream of Putah Creek because of the increase in flooded areas. The costs of the additional flowage easements have not been determined but are considered small in comparison to the first cost of widening the bypass. (The flowage easements could be evaluated in detail during the feasibility phase.) The north levee of the bypass was set back because land north of the bypass is unimproved, whereas the California Highway Patrol Academy is located just to the south of the bypass.

This option also includes extending the weir, and the design of the weir extension will match the existing design. The problems with extending the weir are significant and costly. The UPRR crosses over the weir and must remain open for traffic between Sacramento and Woodland, a city west of the Yolo Bypass. This could be accomplished by building a temporary bypass track, trucking the commodities or rerouting the traffic over another rail line. (The SPRR has indicated that they would probably not grant trackage rights in the area.) Vehicular traffic also crosses over the weir and would have to be diverted or rerouted. First cost and annual costs for widening the bypass by 500 feet (see Figure 34) are $7,200,000 and $640,000, respectively. Widening the bypass by 1,500 feet would have a first cost of $14,900,000 and annual costs of $1,320,000.

Lowering the weir crest and maintaining the same gate operation (no widening of the bypass) would have results similar to widening the weir and

bypass. When the weir crest is lowered, the height of the gate structures would have to be increased the same amount in order to maintain the same operation. As in the case of widening the weir and bypass, additional flowage easements on Yolo Bypass downstream of Putah Creek would be required. The cost of these easements has not been determined, but these costs could be considered in detail during the feasibility phase study. Existing land surface elevations just upstream and downstream of the weir crest are lower than the proposed weir crest elevations being considered. As a result, lowering the weir crest either 0.5 or 1.0 foot would not require removing sediment material just upstream or downstream of the weir. First cost and annual costs for lowering the weir crest elevation by 0.5 foot are $1,500,000 and $130,000, respectively. First cost and annual costs for lowering the weir crest elevation 1.0 foot are $1,750,000 and $160,000, respectively.

As discussed in Chapter IV, "Sacramento River at Verona," one of the operational objectives of the Sacramento and Fremont Weirs is to maintain flows in the Sacramento River to prevent depositional build-up. Any change in the physical configuration or operation of the Sacramento and Fremont Weirs could impact that operational objective. With any proposed changes to the weirs, assurances would be required from local interests to maintain existing flow conveyance within the Sacramento River channel. A monitoring and maintenance program would need to be developed to ensure that channel aggradation would not occur in the Sacramento River channel.

Divert Floodwaters into the Sacramento River Deep Water Ship Channel. - This alternative would divert a portion of the floodwaters in the Yolo Bypass and/or the Sacramento River into the Ship Channel near the Port by pumps and bypasses. Based on information in the section "Hydrologic Evaluation, Comparison of Alternative Plans," diverting flows of 20,000 to 40,000 cfs into the Ship Channel from the Yolo Bypass side would have only a minimal impact on flood stages in the study area for major flood events. As a result, diversion from the Yolo Bypass side was deleted from further consideration.

Hydrologic modeling efforts did indicate that significant reductions in flood stages for major flood events (similar to the 1986 flood event or larger) could be achieved in the Sacramento River downstream of the American River by diverting excess floodwaters from the Sacramento River into the barge canal via the lock. The costs and problems associated with this diversion are significant. Major Port facilities, such as docks, loading cranes, warehouses, etc., would have to be relocated and/or reconstructed because new levees would be required on both sides of the Ship Channel adjacent to the Port. During those periods when floodwaters were diverted into the Ship Channel, ship traffic would be impacted. In fact, ship movement would probably cease. In addition, changes in erosion and deposition in the channel would probably increase dredging costs significantly. Because of these costs and problems, the Sacramento-Yolo Port District (who owns and operates the Port of Sacramento) does not support using the Ship Channel as a diversion channel for floodwaters. Because of the increased costs, potential problems and local opposition, the alternative was deleted from further consideration.

Modify Levees Around West Sacramento. - This alternative involves raising and widening sections of levee to achieve 100- and 200-year levels of flood protection. Construction activities would be limited primarily to the top and landward side of the existing levee embankment.

The design freeboard criterion for both the Yolo and Sacramento Bypasses is 6 feet. The Sacramento River and other streams require 3 feet. On Willow Slough Bypass, there is also a transition reach where the freeboard changes from 6 to 3 feet. Using local stage-frequency curves, high water mark profiles from the 1986 flood event, wind-set criteria and other information, the 100- and 200-year water surface profiles were estimated for design purposes. These profiles, along with levee crown surveys and freeboard criteria, were used to determine whether the levee embankments would need to be increased in height in order to provide a specific level of flood protection. In order to compensate for any adverse flood impacts, levee embankment modifications were also made to levees on the west side of the Yolo Bypass and on the north side of the Sacramento Bypass (see Figures 36 and 37).

First costs and annual costs for this alternative are as follows:

Modify Levees Around West Sacramento
First and Annual Cost Estimates

Level of Flood Protection	First Cost	Annual Cost
100-year	$3,800,000	$340,000
200-year	$6,700,000	$590,000

These costs do not include costs needed to structurally modify the levee embankments to meet the design requirements under existing conditions. As presented in the "Sacramento River Flood Control System Evaluation," Corps of Engineers, May 1988, the cost to structurally repair the existing levees around West Sacramento is estimated at about $2,350,000. Structural repairs might also be needed when improving the levees on the west side of the Yolo Bypass and on the north side of the Sacramento Bypass. These structural repairs, if needed, are currently scheduled to be evaluated in a separate investigation.

Remove Flow Constrictions from Yolo Bypass. - This alternative would consist of replacing highway and railroad embankment material with bridge or culvert structures at I-80 and the SPRR on the Yolo Bypass. The raised embankments reduce flow capacity when compared to pier-supported crossings.

The I-80 crossing over the Yolo Bypass consists of approximately 4,700 linear feet of raised embankment with the remainder being supported by piers. Average daily traffic is 85,000 vehicles with a peak of 100,000 vehicles. During the morning and evening commutes and during Friday and Sunday evenings, the system is near peak capacity. The California Department of Transportation (Caltrans) was consulted on the idea of removing the embankment portion of the I-80 crossing and replacing those sections with piers. Possible alternatives included: (1) build a new permanent pile-supported section parallel and adjacent to the existing embankment portion and then remove the existing embankment section, and (2) build a temporary embankment section next to the existing embankment section, remove the existing embankment section, build a pile-supported section in its place, and then remove the temporary embankment section. All designs would have to satisfy Caltrans freeway standards for speeds of 65 miles per hour, and traffic flow could not be disrupted. Alternative (2) appears to be less costly with an estimated cost of $123 million.

The SPRR crossing consists of three raised embankment sections totaling 9,700 feet, with the remainder being supported by piers. Possible alternative plans include: (1) build a new permanent pile-supported structure with an alignment parallel to the existing line and then remove the existing railroad crossing, and (2) build a temporary elevated shoefly next to the existing line, remove the existing embankment section, build a pile-supported line in its place, and then remove the temporary shoefly. The SPRR line would have to stay open during construction since it is unlikely that trackage rights could be acquired from another railroad to reroute the traffic. Alternative (1) appears to be less costly with an estimated cost of $18 million.

The combined estimated costs for the removal of the embankment sections is about $140 million. Three to four construction seasons would probably be needed to complete the work.

During the meetings with Caltrans, another alternative was discussed. This alternative would consist of jacking concrete pipe through the embankment sections. Caltrans stated that this option would eliminate the need to reroute or delay traffic. They have jacked pipe through embankments in the past, but on a smaller scale. Using 96-inch-diameter pipes, spaced at 12 feet on center, the flow capacity through the pipes would be approximately 30 percent of the capacity that would be achieved by removing the embankment sections. The estimated cost of this alternative would be $245 million.

Benefit Evaluation

Flood damage reduction benefits were based on a comparison of existing and with project condition levels of flood protection in the study area. Estimates of the recurrence intervals at which levee failures could potentially occur under existing conditions were based on levee performance during the February 1986 flood event, expected flood durations, wave action (including wave erosion), bank erosion, the ability of local entities to install floodgates at predetermined locations, magnitude and location of minimum freeboard and stage-frequency curves developed in this reconnaissance study. Locations and associated recurrence intervals of potential levee failures are presented in Table 10. For West Sacramento, the existing level of flood protection is about a 90-year flood event on the Sacramento River side, the Sacramento Bypass side and the Yolo Bypass side of the city (assuming the levee embankments are structurally modified to meet existing design requirements). Minimum freeboard for a 90-year flood event is about 1.6 feet on the Sacramento River near "I" Street, about 2.8 feet on the Sacramento Bypass near the Yolo Bypass levee and about 2.2 feet on the Yolo Bypass. For Area C (see Figure 32) the existing level of flood protection is about a 75-year flood event on the Yolo Bypass and the Sacramento River sides (see Chapter IV, "Average Annual Damages").

The Flood Insurance Administration of FEMA is currently reevaluating the flood hazard potential for the West Sacramento and surrounding areas. Based on reconnaissance level hydrology and the structural evaluation of the levee embankment system ("Sacramento River Flood Control System Evaluation," Corps of Engineers, May 1988), West Sacramento and Area C do not have 100-year levels of flood protection. Because of the uncertainty of future development in these areas, no future growth is being considered in the reconnaissance phase of this study. ER 1105-2-40, 2.4.11(b), "Economic Considerations," July 9, 1983, specifies that future growth considerations are not required if the

benefit-to-cost ratio is above unity and if cost sharing is not affected. Future growth scenarios would be considered in the feasibility phase when more definitive information is available on future development.

As indicated in Chapter IV, "Average Annual Damages," the resulting average annual damages under without project conditions for West Sacramento are about $12 million (assuming no future growth and that structural repairs are implemented). For Area C (under the same assumptions) the average annual damages under without project conditions are about $200,000.

The elevation-damage curves in Figures 31 and 32, updated to 1988 prices and conditions, were used to estimate benefits for each of the flood control alternatives. Depths of flooding and resulting damages for specific flood events are presented in Chapter IV, Technical Studies, "Flood Damages."

Modify Fremont Weir and Yolo Bypass. - Based on existing conditions, about 200,000 cy of additional material would be removed to ensure that land surface elevations both upstream and downstream of the weir are generally no higher than the weir crest elevation of 30.4 feet. With this option, flood stages for the 100-year flood event or an event similar to the 1986 flood event could be reduced between 0.1 and 0.5 foot in the Sacramento River between the confluence with the Feather River and the Sacramento Bypass. The most significant reductions in flood stages would occur near Verona and the Natomas Cross Canal. The reduction in flood stages for the 100-year flood event near the Natomas Cross Canal would also reduce the flood hazard in the Natomas area. The flood control benefits to the Natomas area would easily exceed $2 million on an annual basis. In addition, this option would also increase the level of flood protection to Area C along the Sacramento River from a 75-year level to about a 90-year level. Total average annual benefits attributable to this option is in excess of $2 million.

Widening the Fremont Weir and Yolo Bypass near the weir by 500 feet does not have a significant impact on flood stages in the study area. Widening the Fremont Weir and Yolo Bypass by 1,500 feet has impacts similar to those indicated for the sediment removal option and would result in average annual benefits in excess of $2 million.

Lowering the weir crest about 1.0 foot and removing about 600,000 cy of material near the weir to ensure that land surface elevations both upstream and downstream of the weir are generally no higher than 29.4 feet would reduce flood stages near Verona on the Sacramento River by about 1.5 feet. Average annual benefits would be in excess of $2 million.

In general, the options available for modifying the Fremont Weir and Yolo Bypass near the weir are economically feasible and provide a cost effective approach to providing higher levels of flood protection to the Natomas area. In addition, the options can also increase the level of flood protection and reduce the amount of levee work that would be needed to achieve higher levels of flood protection for Area C, assuming that the levee embankments around Area C are structurally stable at existing design conditions.

Modify Sacramento Weir and Bypass. - Removing the existing gates and forming a smooth concrete surface with a weir crest elevation of 21.2 feet would not impact peak flood stages in the study area for flood events similar

to or larger than the February 1986 flood event. Since peak flood stages that could result in levee failure are similar with or without the gates, no reduction in flood damages has been attributed to this option. It is possible, though, that an ungated overflow structure could reduce the risk that might be associated with manually opening each of the gates. Since manual operation requires a field crew and radio and telephone communication for instructions, there is always the possibility that something could go wrong during flood periods. Benefits that might be attributed to reduced risk because of an ungated structure have not been quantified but could be considered in more detail in feasibility studies (if locals wanted to pursue this option). In addition, an ungated structure would reduce maintenance and operation costs and could reduce the amount of levee improvements required under other flood control alternatives.

Widening the weir and bypass and maintaining the existing gate operation would increase the peak flows over the weir and reduce peak flood stages in the Sacramento River downstream of the weir for major floods similar to or larger than the February 1986 flood event. Even though peak flood stages are reduced in Sacramento River adjacent to south Sacramento (including the Greenhaven area), the level of flood protection would probably not change significantly for that area. Existing levels of flood protection for south Sacramento (from the Sacramento river side) are probably greater than the 200-year flood event. Since peak flood stages are not expected to increase substantially over those indicated for the 200-year event, flood damage reduction benefits attributable to the south Sacramento area are considered insignificant. In addition, adverse flood impacts (although small) resulting from increased flow in Sacramento Bypass and Yolo Bypass would be mitigated to maintain existing levels of flood protection. Since the existing level of flood protection for the West Sacramento area on the Sacramento Bypass and Yolo Bypass sides would be maintained (to meet mitigation requirements), no benefit would result from this option for West Sacramento.

Lowering the weir crest and maintaining the same gate operation would have results similar to widening the weir and bypass. Benefits attributable to this option would also be small.

Divert Floodwaters into the Sacramento River Deep Water Ship Channel. - Based on reconnaissance level evaluations, the costs of this flood control alternative exceed potential benefits. Because of this and local opposition to the alternative, the alternative was deleted from further consideration.

Modify Levees Around West Sacramento. - Based on Table 10, the estimated level of flood protection for West Sacramento is about a 90-year flood event. Actual levee failures may occur at higher or lower recurrence intervals (flood stages), depending on flood duration, wave action, bank erosion, emergency efforts, etc. The 90-year level of flood protection assumes that the levee embankments are structurally stable and that any necessary structural repairs recommended in the "Sacramento River Flood Control System Evaluation," Corps of Engineers, May 1988, will be implemented prior to any improvements in this study. (Structural repairs estimated for the levees around West Sacramento cost between $2 and $3 million.)

Raising and widening levee embankments around West Sacramento to provide design levels of flood protection for the 100-year and 200-year flood events would reduce potential flood damages to West Sacramento and the Port. In

accordance with planning guidance for determining flood damage prevention benefits in the freeboard range, benefits are claimed for one-half of the area under the frequency-damage curve between the design level of protection and the largest flood that might be carried within the freeboard.

As indicated in the section "Flood Damages," the estimated flood damages in West Sacramento from the 100-year and 200-year flood events (under existing conditions) are $850 million and $1.2 billion, respectively. Average annual damages under without project conditions are about $12 million based on an existing 90-year level of flood protection. Under with project conditions for 100-year and 200-year design levels, average annual benefits would be about $6.5 and $9 million, respectively.

Remove Flow Constrictions from Yolo Bypass. - Replacing highway and railroad embankment material with bridge or culvert structures at I-80 and the SPRR on the Yolo Bypass would reduce flood stages in the Yolo and Sacramento Bypasses adjacent to West Sacramento. For a major flood event, removal of the embankment material could reduce flood stages in the Yolo and Sacramento Bypasses upstream of I-80 and adjacent to West Sacramento between 0.5 and 1.0 foot. Reductions in flood stages in the Sacramento River and the Yolo Bypass above Woodland are relatively insignificant.

Average annual damages for the West Sacramento area under without project conditions are about $12 million (assuming an existing 90-year level of flood protection, significant wave action and no flood fighting efforts). The combined estimated construction costs for the removal of the embankment sections is about $140 million. Any benefits attributable to the reduction in flood stages is not significant enough to justify the high costs associated with embankment removal. (No significant change in the level of flood protection would occur on the Sacramento River side of West Sacramento.)

Summary

Information developed during the reconnaissance level evaluation of the benefits and costs of the various flood control alternatives is presented in Table 11. These alternatives have been evaluated based on a 50-year project life (1995-2045), 8-5/8 percent discount rate and 1988 price levels.

Two of the alternatives considered, diverting floodwaters into the Ship Channel and removing flow constrictions from the Yolo Bypass (I-80 and the SPRR embankments), have very high costs and potential adverse impacts. The high cost for using the Ship Channel as a temporary flood control channel results from the need for new levees on both sides of the channel adjacent to the Port and associated relocation and reconstruction of major Port facilities, such as docks, loading cranes, warehouses, etc. The high cost involved in the removal of embankment material from I-80 results from Caltrans' concern and need to avoid traffic disruption on the interstate highway system. In addition, the Sacramento-Yolo Port District, who owns and operates the Port of Sacramento, does not support using the Ship Channel as a diversion channel for floodwaters because of potential impacts to ship traffic.

Modification of the Sacramento Weir and Bypass has only a minimal impact on reducing potential flood damages. Removing the existing gates and forming a smooth concrete surface with a crest elevation of 21.2 feet have no

TABLE 11

Economic Summary of Alternatives
(1988 Price Level, 8-5/8% Discount Rate, 1995-2045 Project Life, $1,000)

Flood Control Alternatives 1/	First Cost Construction	First Cost Environmental	Annual Cost 2/	Annual Benefit	B/C Ratio
Modify Fremont Weir and Yolo Bypass					
Remove material	650	100	130	2,000 3/	15.4+
Widen 500 feet	9,000	1,000	925	minimal	--
Widen 1,500 feet	13,400	1,000	1,305	2,000 3/	1.5+
Lower weir 0.5 feet	1,470	100	200	2,000 3/	10+
Lower weir 1.0 feet	2,035	100	250	2,000 3/	8+
Modify Sacramento Weir and Bypass					
Remove existing gates	85	--	10	minimal 4/	--
Widen 500 feet	7,200	60	645	minimal	--
Widen 1,500 feet	14,900	60	1,325	minimal	--
Lower weir 0.5 feet	1,500	--	130	minimal 4/	--
Lower weir 1.0 feet	1,750	--	160	minimal 4/	--
Divert Floodwaters into the Sacramento River Deep Water Ship Channel	Preliminary evaluations indicate costs significantly greater than benefits (see text)				
Modify Levees around West Sacramento					
100-year plan	3,800	100	350	6,500	18.5
200-year plan	6,700	150	610	9,000	15
Remove Flow Constrictions from Yolo Bypass					
I-80 and the SPRR.	141,000	200	12,500	significantly less than annual cost	--

1/ Assumes levees are structurally stable under existing design conditions.
2/ Includes monitoring, maintenance and environmental costs.
3/ Annual benefits are in excess of $2 million and are primarily attributable to the Natomas area.
4/ Benefits attributable to an ungated overflow structure have not been evaluated in sufficient detail other than for flood damage reduction benefits. Benefits attributable to reduced risk (elimination of the manual operation), reduced maintenance and operation costs and reduced amounts of levee improvements associated with other flood control alternatives have not been quantified. Because of the low cost of these options, a detailed benefit evaluation could indicate the options are economically feasible.

February 1989

significant impact on peak flood stages similar to or larger than the February 1986 flood event in the study area. Widening the weir and bypass or lowering the weir crest would increase peak flows over the weir and would decrease peak flood stages in the Sacramento River downstream of the weir. Adverse flood impacts (although small) attributed to increased flow in the Sacramento Bypass and Yolo Bypass would be mitigated to maintain existing levels of flood protection. Existing levels of flood protection along the Sacramento River downstream of the Sacramento Bypass (on the south Sacramento side) are greater than the 200-year flood event (see Table 10). Since peak flood stages are not expected to increase substantially over those indicated for the 200-year event (see Chapter IV, "Stage-Frequency Analysis"), flood damage reduction benefits attributable to the south Sacramento area are considered insignificant. Also, since the existing level of flood protection for the West Sacramento area on the Sacramento Bypass and Yolo Bypass sides would not change, no benefit would result from this option for West Sacramento.

As indicated in Table 11, the flood control alternatives that are economically feasible include modifications to the Fremont Weir and Yolo Bypass and levee improvements for the city of West Sacramento. Most options considered for the Fremont Weir and vicinity have a benefit-to-cost ratio of 1.5 and greater. All options will result in small increases in water surface elevation (because of increased flow over the weir) in the Yolo Bypass between the Fremont Weir and Sacramento Bypass for major flood events. These adverse flood impacts would be mitigated to maintain existing levels of flood protection adjacent to the Yolo Bypass. Flood control benefits attributable to the Fremont Weir options are primarily in the Natomas area because of reduced peak flood stages in the Sacramento River near the Natomas Cross Canal. For the West Sacramento area, 100-year and 200-year design levels of flood protection (attained by raising existing levees) result in about $6.5 and $9 million in average annual benefits and benefit-to-cost ratios of 18.5 to 1 and 15 to 1, respectively.

CHAPTER VI - FEASIBILITY PHASE STUDIES

NON-FEDERAL SPONSOR'S VIEWS

Current Federal cost-sharing laws require that a non-Federal local sponsor share 50 percent of the feasibility phase study costs. Therefore, the local sponsor will have a strong financial interest in those studies. In a letter dated February 10, 1989, The Reclamation Board of the State of California offered to be the local sponsor for feasibility studies (see Attachment). The Reclamation Board is coordinating with other local interests to cost share in the 50 percent local portion.

Representatives from The Reclamation Board and other supporting agencies have indicated strong support for studies of the alternative plans identified in this reconnaissance study. For example, in a letter dated July 7, 1988, Reclamation District 1000 indicated an interest in reoperation and modification of Fremont Weir because of sediment build-up and the existing weir elevation. Also, the City of West Sacramento and Reclamation District 900 have indicated an interest in raising levees around West Sacramento.

PUBLIC INVOLVEMENT

A scoping notice outlining the investigation and proposed alternatives was sent to public agencies and organizations in the Sacramento area. The purpose of the scoping notice was to identify information on significant natural resources in the study area. Responses to the scoping notice were considered in preparation of the Environmental Information Paper.

During feasibility studies, a public involvement program will include information bulletins, meetings with special interest groups, and a formal public meeting to be held near the conclusion of the study.

REQUIRED STUDIES

A large number of studies will be required during the feasibility phase of the investigation. A scope of work, cost estimate, and schedule for the feasibility study are appended to a Feasibility Cost-Sharing Agreement (FCSA). The FCSA is between the Department of the Army (represented by the Sacramento District Engineer) and the non-Federal sponsor (The Reclamation Board) and identifies the equal sharing of costs for the feasibility study. A draft FCSA and Scope of Studies (SOS) is included in this report (see Attachment 2 and 3). Accompanying submission of the FCSA for approval is a letter of intent from the non-Federal sponsor stating that the FCSA is acceptable and that the sponsor will sign the agreement upon certification of the reconnaissance report.

STUDY MANAGEMENT

The non-Federal sponsor will be involved in study management. In order to manage a cost-shared study, an Executive Committee and a Study Management Team will be formed. This management structure will be formalized in the FCSA.

The Study Management Team will include the Corps, the non-Federal sponsor and the sponsor's cost-sharing partners. This team will develop the studies,

guide in their accomplishment, and participate in selection of potential solutions. The team will be directly involved in establishing mutual roles and in focusing on the critical issues. Corps representatives will include the study manager and the Chief, Sacramento River Basin Branch, Planning Division. The team will recommend to the Executive Committee the tasks to be conducted and extent of planning and evaluation to be carried out in the feasibility phase. It will also report on the results of studies to the Committee and recommend alternative courses of action for project implementation.

The Executive Committee will include the District Engineer and his chief planner or designee. The sponsor and the sponsor's cost-sharing participants, along with primary technical advisors, will be equal partners with the Corps representatives on the Committee. The District Engineer and his counterpart with the State of California (President, The Reclamation Board) will co-chair the Committee. Other members of the Executive Committee are likely to be from West Sacramento, Yolo County and Reclamation Districts 900, 537 and 811.

The Executive Committee will participate in Issue Resolution Conferences (IRC) and ratify decisions made by the Study Management Team. The Committee is also responsible for resolving any disputes that may arise during the study. The Committee will agree on the solutions and study direction, which may include termination. At least one IRC will be held prior to the public distribution of the draft feasibility report to ensure that all issues are resolved prior to submitting the final report to higher authority. Additional IRC's will be held, as required, throughout the study to resolve any problems that may arise.

The Corps study manager will be required to perform both the general supervision of personnel involved in the study and the management of the study itself. He will ensure that funds are allocated to the proper organizational elements and that appropriate analyses are conducted to develop the information needed to evaluate the resource problems in the study area. He will also direct the flow of technical information between the Corps and the local sponsor in order to accomplish the work in an efficient and timely manner.

A Life Cycle Project Manager (LCPM) will be assigned to this study prior to signing the FCSA. The LCPM's primary role is to manage the overall project from the development of the FCSA through construction. The LCPM will be the primary point of contact with the non-Federal sponsor for items regarding schedule, funds and overall project development.

FINANCIAL ANALYSIS

Feasibility Phase

The feasibility phase will be cost shared 50 percent Federal/50 percent non-Federal. The State of California will divide the non-Federal costs among the recipients of the benefits of the proposed plan. Study costs will be funded from the yearly working budgets of these organizations. The non-Federal fiscal year begins in July, and the study costs for the first year have been set aside in their respective budgets.

Construction Phase

The cost of constructing the project will be shared in accordance with the Water Resources Development Act of 1986. During construction of a project, the non-Federal sponsor must pay 5 percent of the costs assigned to flood control. In addition, the sponsor must provide all lands, easements, rights-of-way, and relocations. If the total of the two of these is less than 25 percent of the total project cost, the sponsor will pay the difference during construction. However, the total non-Federal cost will not exceed 50 percent of the total project cost.

CHAPTER VII - DISCUSSION AND CONCLUSIONS

Reconnaissance phase evaluations of the Sacramento metropolitan area indicate that the city of West Sacramento and Area C (that area between the Yolo Bypass and the Sacramento River north of the Sacramento Bypass) have less than 100-year levels of flood protection. The south Sacramento area (including the Greenhaven area) adjacent to the Sacramento River has a high level of flood protection (probably equal or greater than 200-year flood protection) from potential flooding from the Sacramento River. For all areas within the study area, it is assumed that the existing levee embankments are structurally stable under existing design conditions.

The Corps has initiated a comprehensive evaluation of the structural stability of project (Federal) levees under the Sacramento River Flood Control System Evaluation, a separate study authority from this reconnaissance investigation. The Corps is also seeking approval to construct any needed modifications to bring the levees up to recommended design strengths under the same authority. (Levee modifications under this program do not include any changes in the design levee crown elevations.)

The stage-frequency analyses conducted in this study indicate that the recurrence interval of the February 1986 flood event ranged between 90 and 120 years. In addition, the relatively flat slopes of the stage-frequency curves indicate about a 1.0-foot difference in peak flood stages between a 90-year and 200-year event. Minimum levee embankment freeboards observed during the February 1986 flood event were 1.0 foot for Area C and 1.4 feet for West Sacramento on the Sacramento River side and 1.3 feet for Area C and 2.0 feet for West Sacramento on the Yolo Bypass side. The minimum observed freeboards and the estimated recurrence interval of the 1986 flood event suggest design levels of flood protection significantly less than a 100-year flood event. Design freeboard is 3 feet and 6 feet on the Sacramento River and Yolo Bypass, respectively.

Economic analyses indicate that levee embankment improvements for the city of West Sacramento are economically justified with benefit-to-cost ratios ranging between 15 and 20 to 1, depending on the level of flood protection provided. The total estimated first cost for achieving 100-year and 200-year design levels of flood protection for West Sacramento are about $4 million and $7 million, respectively. Flood control alternatives involving modifications to the Fremont Weir and Yolo Bypass near the weir are also economically justified, but the benefits derived are primarily attributable to the Natomas area. Total estimated first costs of modifying the weir and bypass range between $1 million and $15 million, depending on the option selected. These alternatives would provide in excess of $2 million in average annual flood control benefits for the Natomas area.

Several concerns were brought to our attention late in this reconnaissance study. The estimated construction cost to provide a 100-year design level of flood protection for Area C is about $4 million (assuming the levee embankments are structurally stable at existing design conditions). The average annual cost is about $350,000. Since the area is predominately agricultural, average annual benefits possible are about $150,000. The benefit-to-cost ratio is significantly less than one. Because one of the

Corps' objectives is to reduce potential flood damages in urban areas, this particular alternative was not considered initially. However, a problem could exist if this area does not have the same design level of flood protection as Natomas. If the levees around Area C on the north side failed early in a major flood event, this area could fill to significant depths and eventually overtop the levees on the south side near the Sacramento Bypass. Early breaching of levees around Area C and floodwaters leaving and re-entering the system unexpectedly could impact the effective and prescribed operating procedure for the Sacramento Weir. In general, opening of the gates under a breached scenario would lag behind opening of the gates without a levee failure. Whether or not this condition could adversely impact the operation of the flood control project in the study area would have to be evaluated in detail in the feasibility studies.

The above problem could be intensified when considering structural stability under existing conditions. If the levee embankments around Natomas, south Sacramento and West Sacramento are repaired to meet structural stability specified in the Sacramento River Flood Control System Evaluation and Area C levees are left in their present condition, it is possible that Area C would have a level of flood protection significantly less than any of the surrounding areas. The on-going structural analysis is just beginning to collect information on the levee embankments around Area C. If structural problems are determined, the costs of those repairs will probably not be economically justified based on benefits attributable to the agricultural lands within that area. In such a case the system could not perform as designed under existing conditions and may not perform as expected when surrounding areas have increased levels of flood protection.

Since flood control alternatives involving modifications to the Fremont Weir and Yolo Bypass near the weir primarily benefit the Natomas area, those alternatives are being transferred to the feasibility phase of the American River Watershed investigation. The Reclamation Board, the non-Federal sponsor, concurred in this transfer. Since local entities that would benefit most from these alternatives, particularly the City and County of Sacramento and Reclamation District 1000, are already providing funds toward the feasibility phase of the American River Watershed investigation, the Corps and The Reclamation Board feel it is appropriate to make that transfer.

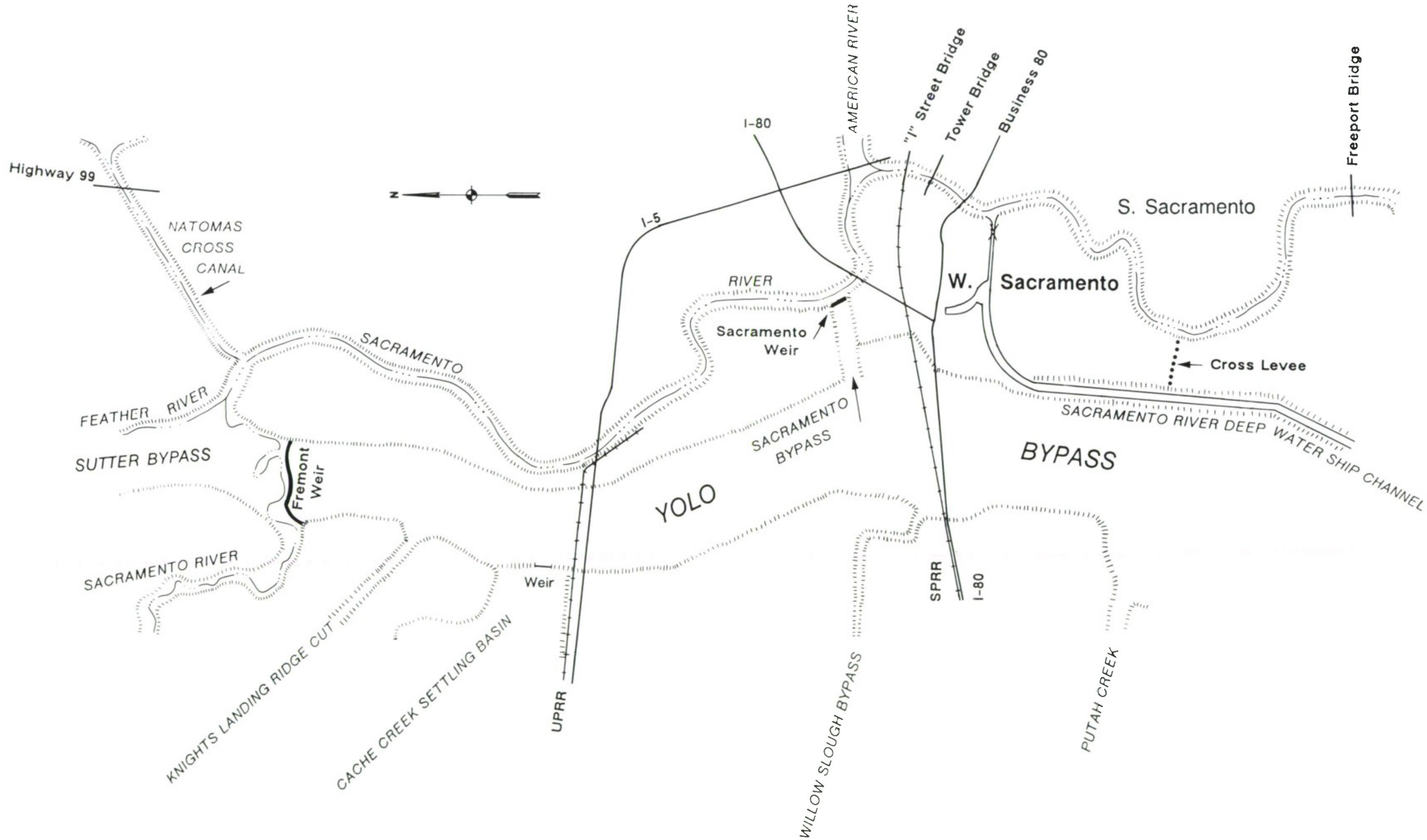
In the remaining Sacramento Metropolitan study area, local interests have expressed a reluctance to be involved in a regional solution that includes a dry dam or multi-purpose facility at or near the Auburn Dam site. These interests have agreed to provide funds to the Sacramento Metropolitan Area feasibility study based on the transfer of Fremont Weir alternatives to the American River Watershed investigation. The alternatives that would remain in the Sacramento Metropolitan Area studies which have been approved by The Reclamation Board, the city of West Sacramento, and Reclamation Districts 900, 537 and 811 include levee improvements for the West Sacramento area and modifications to the Sacramento Weir and Bypass. In addition, it is understood that the Corps will continue to evaluate the levee system for the south Sacramento area, although there appears to be ample freeboard for major flood events based on current hydrologic information.

Although The Reclamation Board has agreed to be the local sponsor for the feasibility phase of the Sacramento Metropolitan Area investigation, the city of West Sacramento, Yolo County, and Reclamation Districts 900, 537 and 811 could provide funds for a portion of the non-Federal share. These other local interests would like an expedient solution to their flood problems.

CHAPTER VIII - RECOMMENDATIONS

The results of this reconnaissance study indicate that there is a Federal interest in at least one potential flood control alternative in the Sacramento metropolitan study area. This alternative has local support, appears economically feasible, and has a local sponsor that is willing and able to cost share the feasibility phase. Therefore, I recommend that feasibility studies for the Sacramento Metropolitan Area Investigation be initiated.

Jack A. Le Cuyer
Jack A. Le Cuyer
Colonel, Corps of Engineers
District Engineer



LEGEND

FEDERAL LEVEES
PRIVATE LEVEES

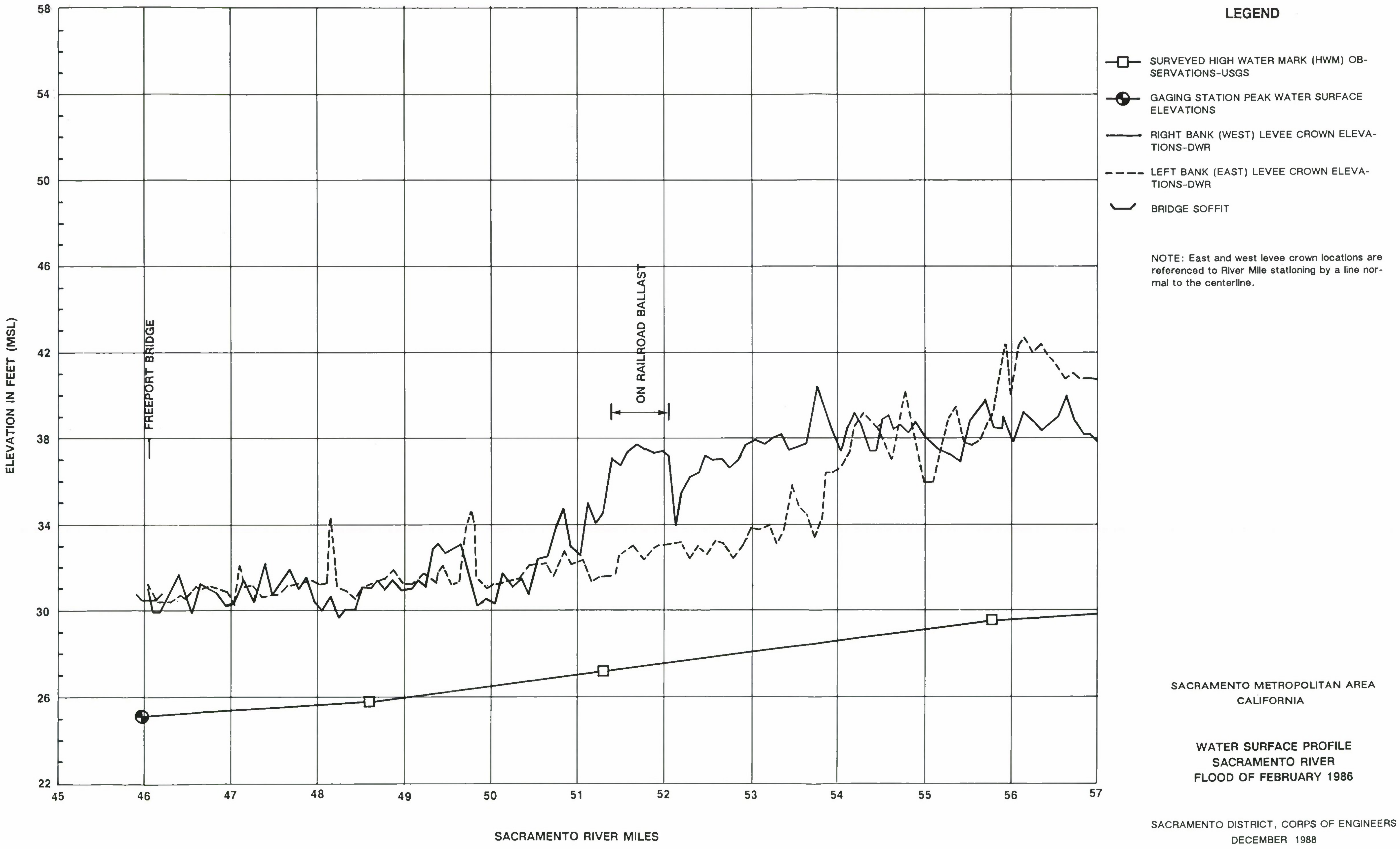
NOT TO SCALE

SACRAMENTO METROPOLITAN AREA
CALIFORNIA

STUDY AREA

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
DECEMBER 1988

PLATE 1

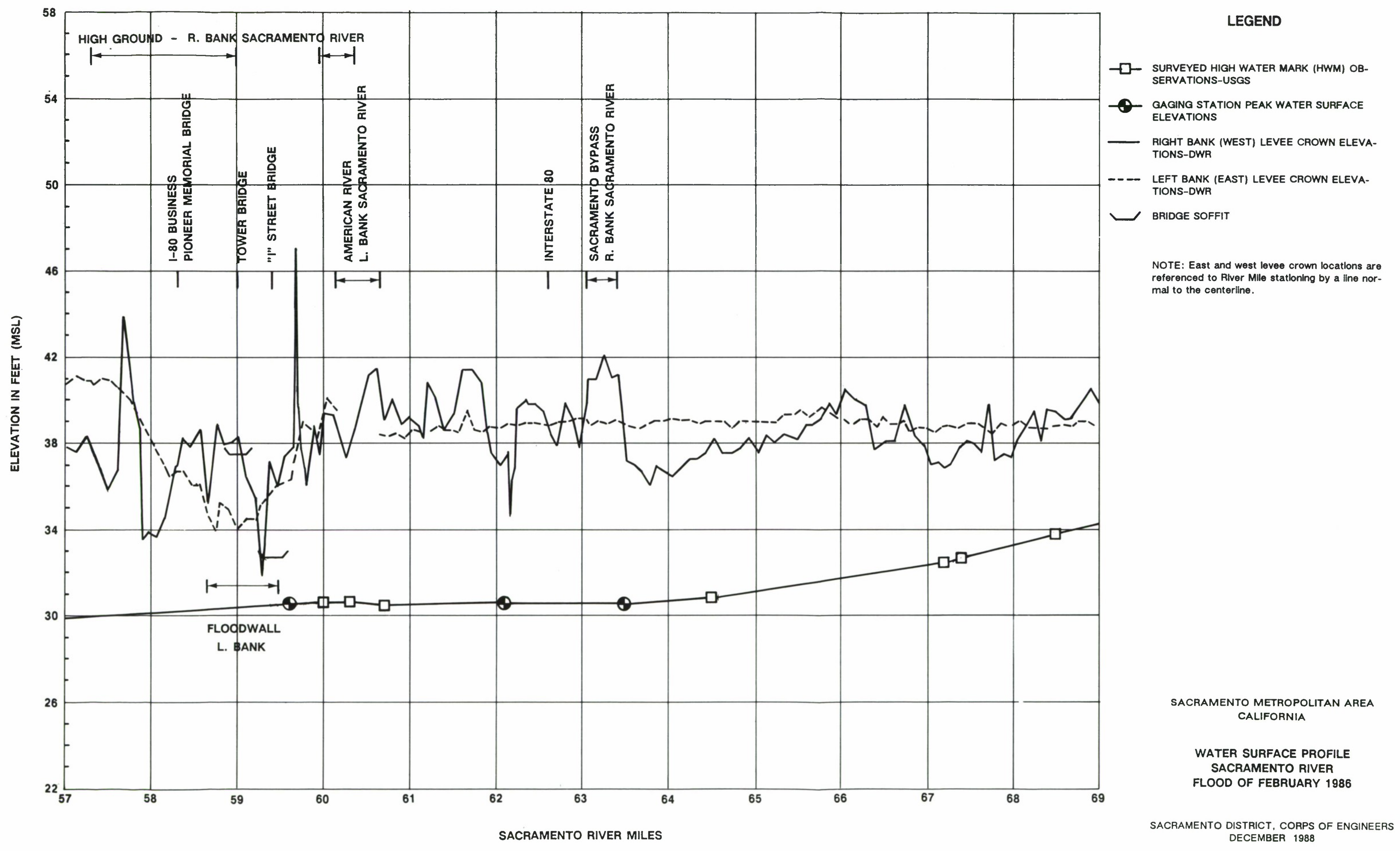


SACRAMENTO METROPOLITAN AREA
CALIFORNIA

WATER SURFACE PROFILE
SACRAMENTO RIVER
FLOOD OF FEBRUARY 1986

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
DECEMBER 1988

SHEET 1 OF 3 PLATE 2

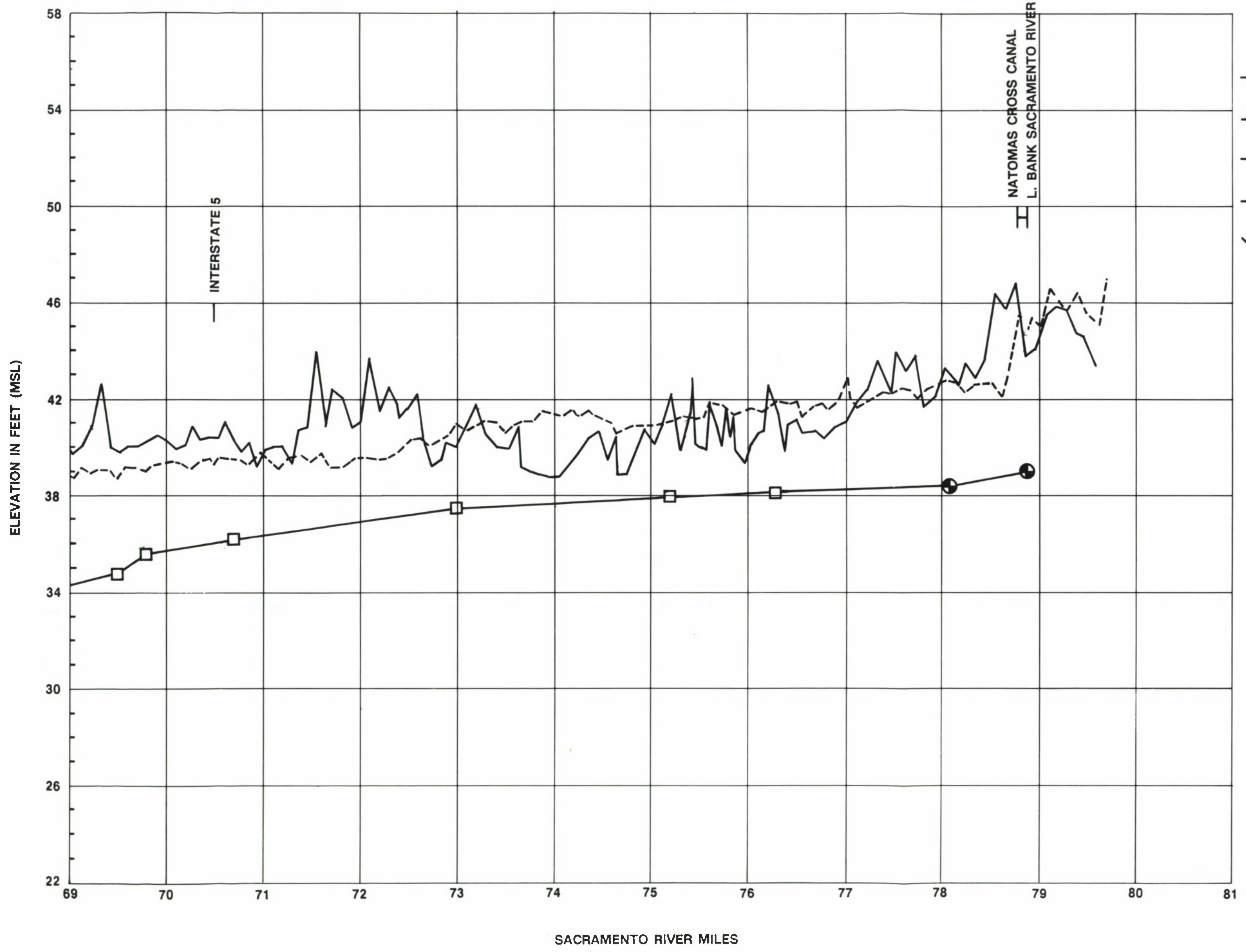


SACRAMENTO METROPOLITAN AREA
CALIFORNIA

WATER SURFACE PROFILE
SACRAMENTO RIVER
FLOOD OF FEBRUARY 1986

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
DECEMBER 1988

SHEET 2 OF 3 PLATE 2



LEGEND

- SURVEYED HIGH WATER MARK (HWM) OBSERVATIONS-USGS
- GAGING STATION PEAK WATER SURFACE ELEVATIONS
- RIGHT BANK (WEST) LEVEE CROWN ELEVATIONS-DWR
- LEFT BANK (EAST) LEVEE CROWN ELEVATIONS-DWR
- BRIDGE SOFFIT

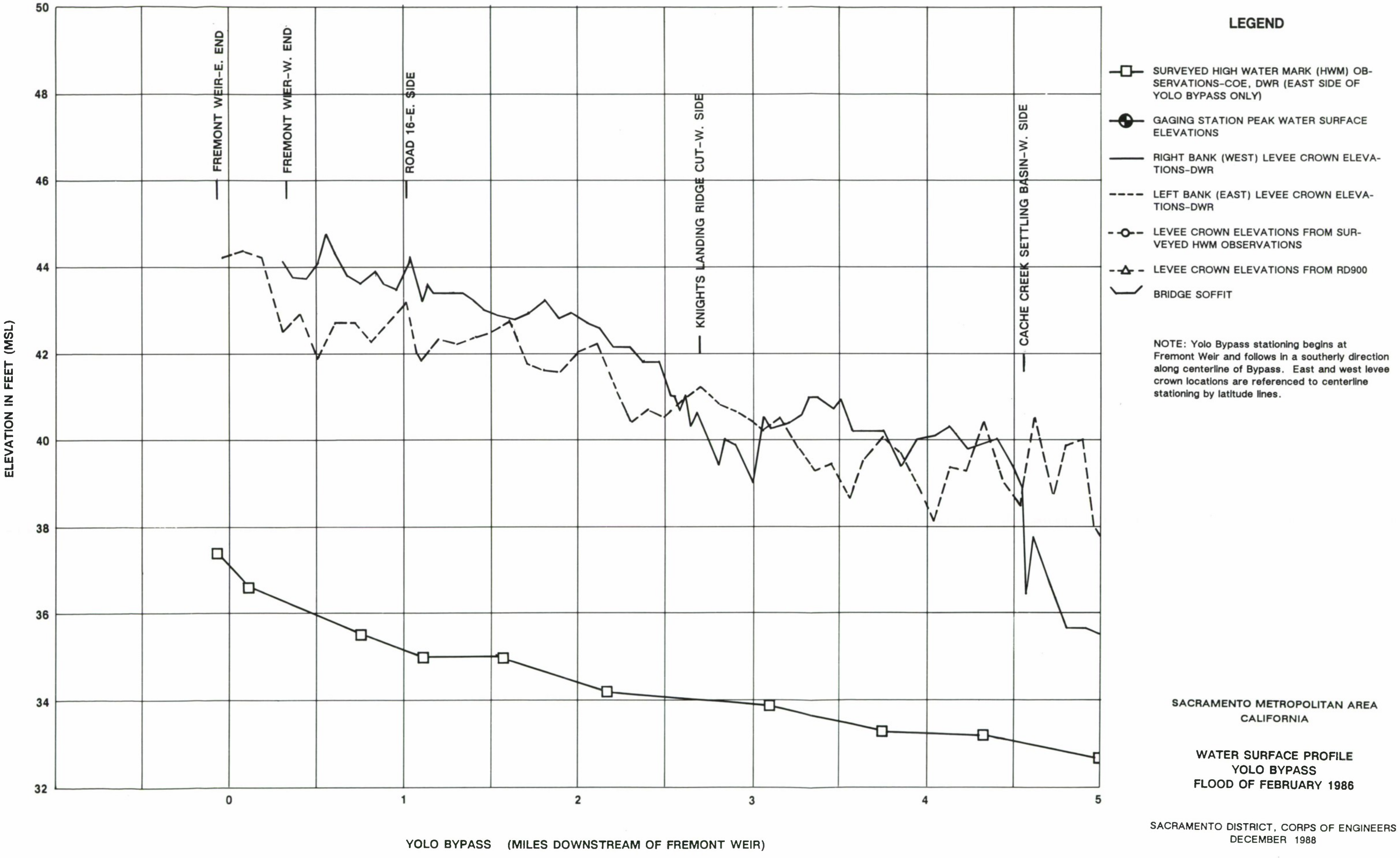
NOTE: East and west levee crown locations are referenced to River Mile stationing by a line normal to the centerline.

SACRAMENTO METROPOLITAN AREA
CALIFORNIA

WATER SURFACE PROFILE
SACRAMENTO RIVER
FLOOD OF FEBRUARY 1986

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
DECEMBER 1988

SHEET 3 OF 3 **PLATE 2**

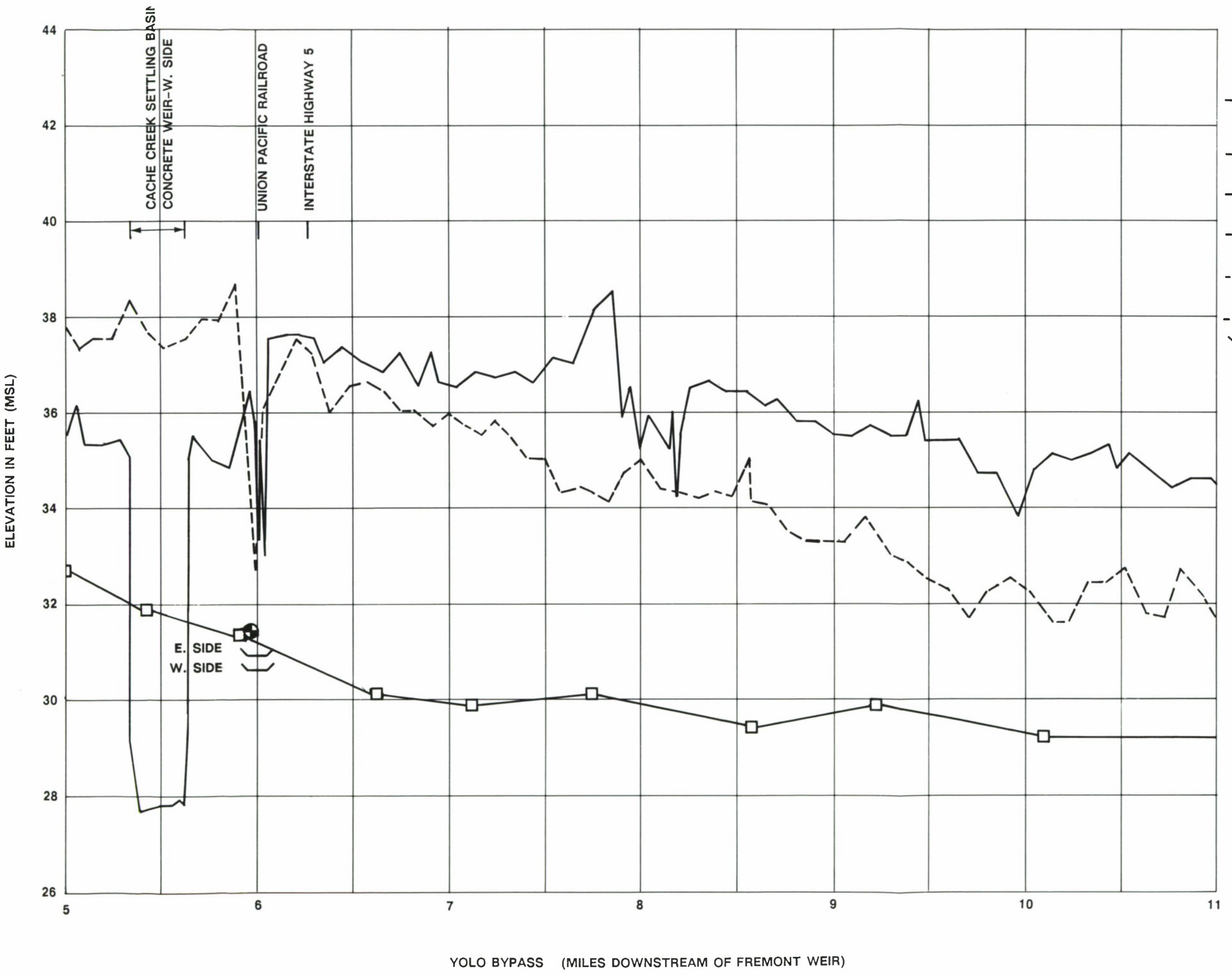


SACRAMENTO METROPOLITAN AREA
CALIFORNIA

WATER SURFACE PROFILE
YOLO BYPASS
FLOOD OF FEBRUARY 1986

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
DECEMBER 1988

SHEET 1 OF 4 PLATE 3



LEGEND

- SURVEYED HIGH WATER MARK (HWM) OBSERVATIONS-COE, DWR (EAST SIDE OF YOLO BYPASS ONLY)
- GAGING STATION PEAK WATER SURFACE ELEVATIONS
- RIGHT BANK (WEST) LEVEE CROWN ELEVATIONS-DWR
- LEFT BANK (EAST) LEVEE CROWN ELEVATIONS-DWR
- LEVEE CROWN ELEVATIONS FROM SURVEYED HWM OBSERVATIONS
- LEVEE CROWN ELEVATIONS FROM RD900
- BRIDGE SOFFIT

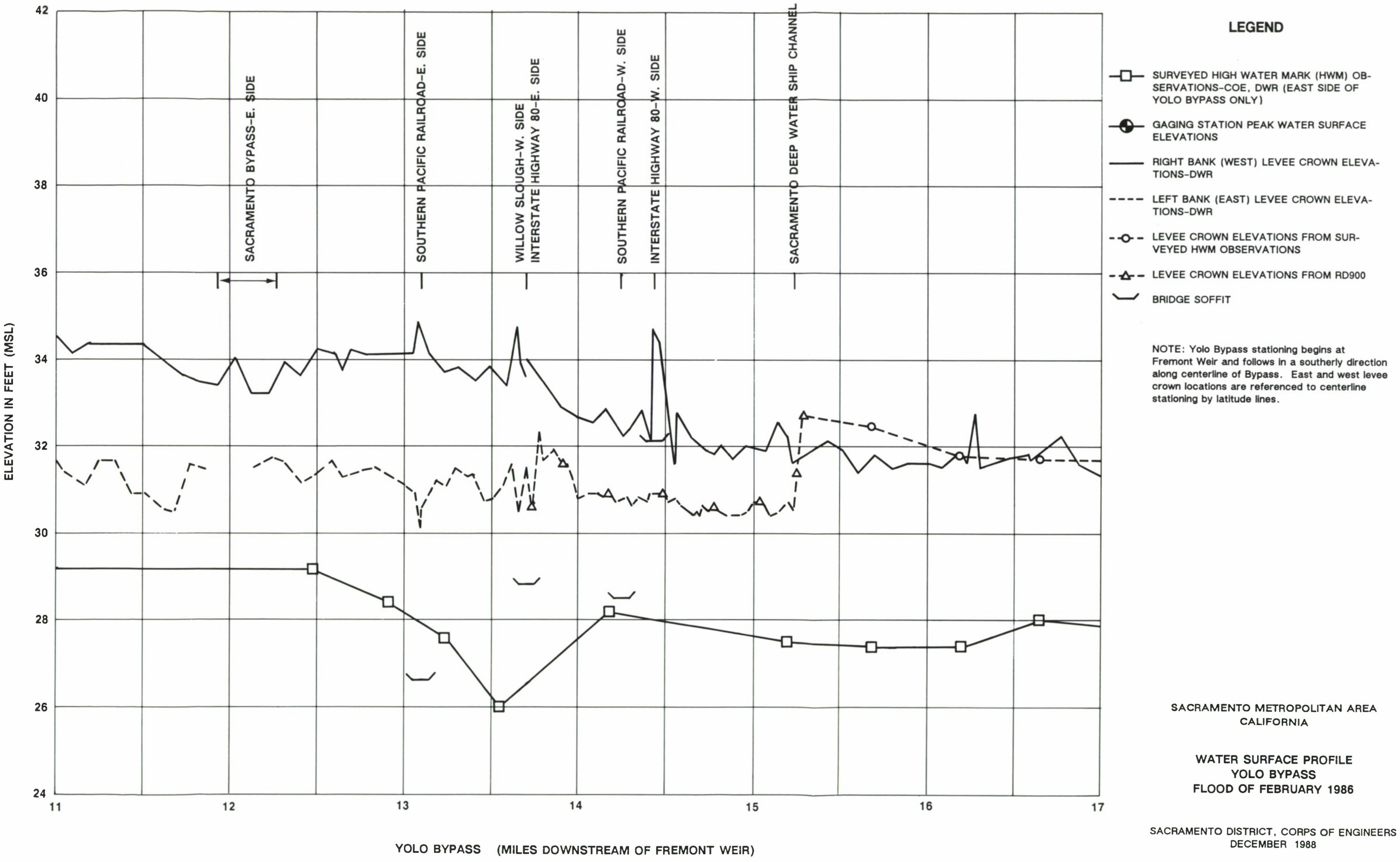
NOTE: Yolo Bypass stationing begins at Fremont Weir and follows in a southerly direction along centerline of Bypass. East and west levee crown locations are referenced to centerline stationing by latitude lines.

SACRAMENTO METROPOLITAN AREA
CALIFORNIA

WATER SURFACE PROFILE
YOLO BYPASS
FLOOD OF FEBRUARY 1986

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
DECEMBER 1988

SHEET 2 OF 4 **PLATE 3**



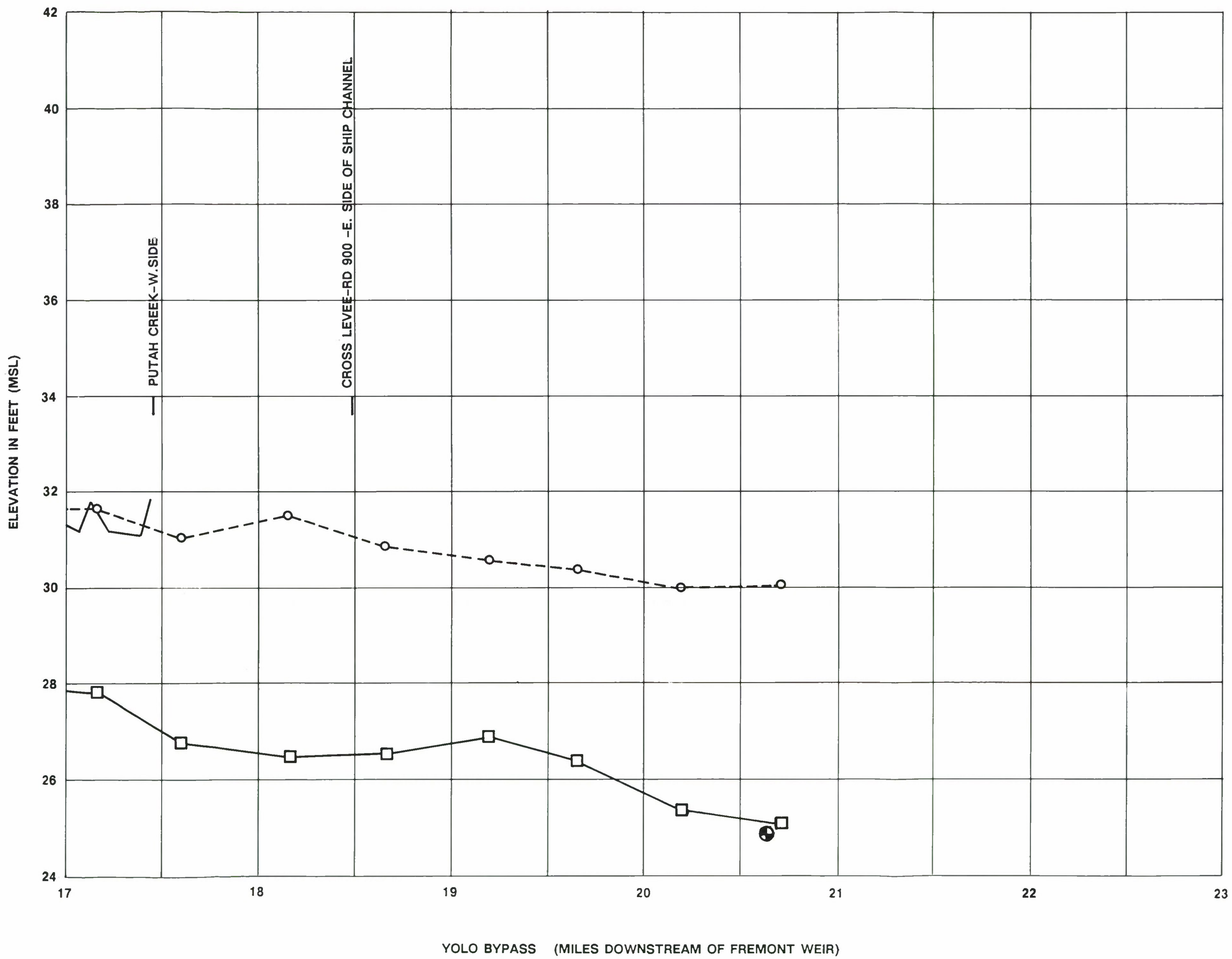
NOTE: Yolo Bypass stationing begins at Fremont Weir and follows in a southerly direction along centerline of Bypass. East and west levee crown locations are referenced to centerline stationing by latitude lines.

SACRAMENTO METROPOLITAN AREA
CALIFORNIA

WATER SURFACE PROFILE
YOLO BYPASS
FLOOD OF FEBRUARY 1986

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
DECEMBER 1988

SHEET 3 OF 4 PLATE 3



LEGEND

- SURVEYED HIGH WATER MARK (HWM) OBSERVATIONS-COE, DWR (EAST SIDE OF YOLO BYPASS ONLY)
- GAGING STATION PEAK WATER SURFACE ELEVATIONS
- RIGHT BANK (WEST) LEVEE CROWN ELEVATIONS-DWR
- LEFT BANK (EAST) LEVEE CROWN ELEVATIONS-DWR
- LEVEE CROWN ELEVATIONS FROM SURVEYED HWM OBSERVATIONS
- LEVEE CROWN ELEVATIONS FROM RD900
- BRIDGE SOFFIT

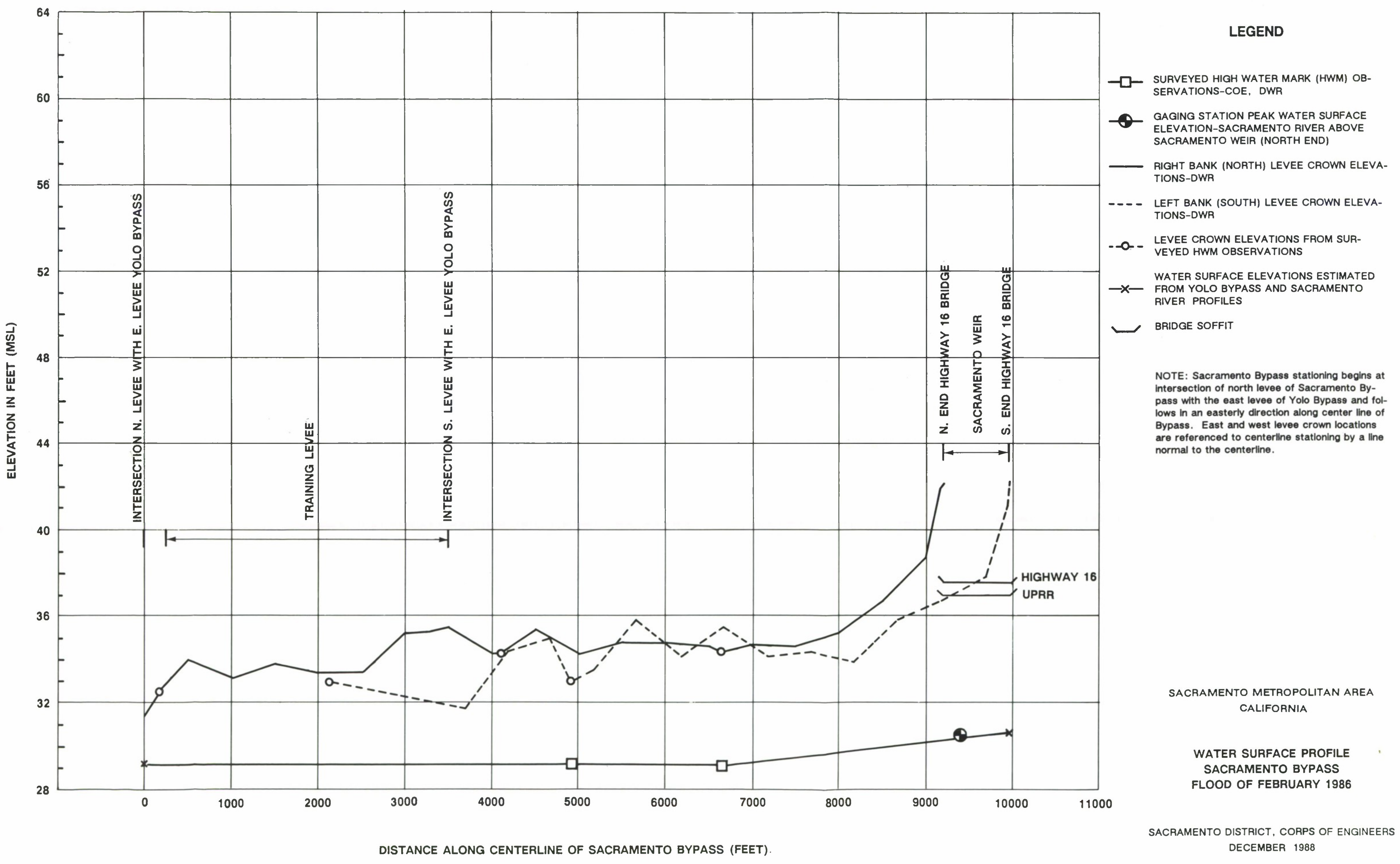
NOTE: Yolo Bypass stationing begins at Fremont Weir and follows in a southerly direction along centerline of Bypass. East and west levee crown locations are referenced to centerline stationing by latitude lines.

SACRAMENTO METROPOLITAN AREA
CALIFORNIA

WATER SURFACE PROFILE
YOLO BYPASS
FLOOD OF FEBRUARY 1986

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
DECEMBER 1988

SHEET 4 OF 4 PLATE 3



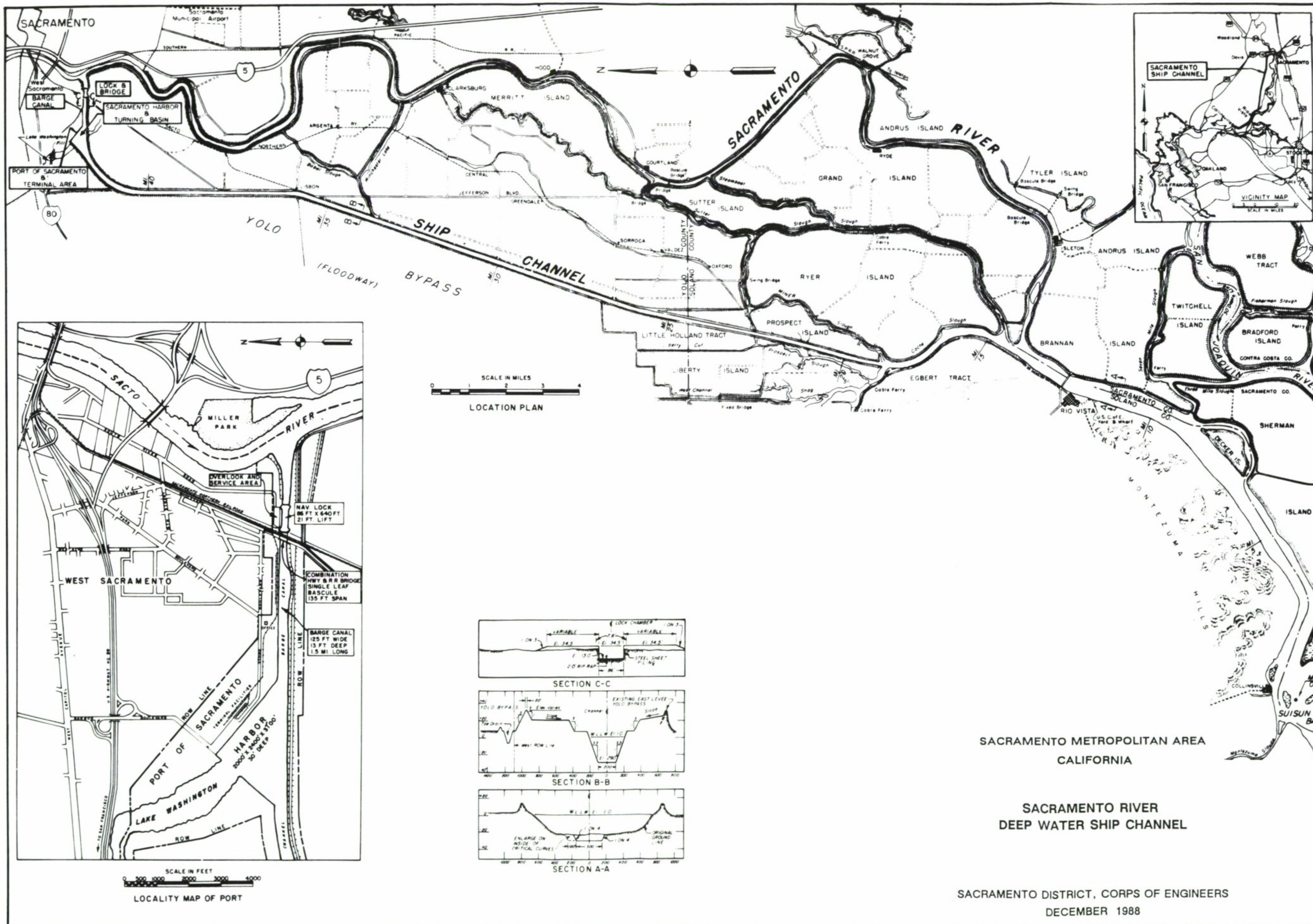
NOTE: Sacramento Bypass stationing begins at intersection of north levee of Sacramento Bypass with the east levee of Yolo Bypass and follows in an easterly direction along center line of Bypass. East and west levee crown locations are referenced to centerline stationing by a line normal to the centerline.

SACRAMENTO METROPOLITAN AREA
CALIFORNIA

WATER SURFACE PROFILE
SACRAMENTO BYPASS
FLOOD OF FEBRUARY 1986

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
DECEMBER 1988

PLATE 4



SACRAMENTO METROPOLITAN AREA
CALIFORNIA

SACRAMENTO RIVER
DEEP WATER SHIP CHANNEL

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
DECEMBER 1988

PLATE 5

ATTACHMENT 1

LETTER OF INTENT FROM THE RECLAMATION BOARD

STATE OF CALIFORNIA—RESOURCES AGENCY GEORGE DEUKMEJIAN, *Governor*

THE RECLAMATION BOARD
1416 Ninth Street, Room 455-6
Sacramento, CA 95814
(916) 445-9454

February 10, 1989

Colonel Jack A. Le Cuyer
District Engineer
Sacramento District
U. S. Army Corps of Engineers
650 Capitol Mall
Sacramento, CA 95814

Dear Colonel Le Cuyer:

This is to inform you that The Reclamation Board intends to be the nonfederal sponsor of the feasibility phase of the Sacramento Metropolitan Area investigation.

The Reclamation Board also concurs with and approves of the transfer of a portion of the study area into the feasibility phase of the American River Watershed Investigation. In meetings between members of our staff and the Corps of Engineers, Corps personnel indicated that flood control alternatives (evaluated in the reconnaissance study) involving modifications to the Fremont Weir and Yolo Bypass near the weir would primarily benefit the Natomas area. These alternatives could influence the scope of alternatives developed in the American River Watershed investigation to achieve higher levels of flood protection for Natomas. In particular, work at the Fremont Weir could potentially reduce the extent of, or, possibly the need for a gated structure and pumping facility at the mouth of the Natomas Cross Canal, bridge replacements and modifications on the Natomas Cross Canal and Pleasant Grove Creek Canal, and levee raising on the Sacramento River downstream of the Natomas Cross Canal. Since local entities that would benefit most from these alternatives, particularly the City and County of Sacramento and Reclamation District 1000, are already providing funds toward the feasibility phase of the American River Watershed Investigation, we feel it is appropriate to make this transfer. We also understand that the transfer of a portion of the study area to the American River Watershed Investigation could increase the costs of that feasibility study and involve other local interests.

In the remaining Sacramento Metropolitan study area, local interests have expressed a reluctance to be involved in a regional solution that includes a dry dam or multi-purpose facility at or near the Auburn Dam site. These interests have agreed to provide funds to the Sacramento Metropolitan

feasibility study based on the transfer of this study area. The alternatives that would remain in the Sacramento Metropolitan Area Investigation and in which the Board, the City of West Sacramento, and Reclamation Districts 900, 537 and 811 are interested in pursuing include levee improvements for the West Sacramento area and modifications to the Sacramento Weir and Bypass. The Yolo County Flood Control and Water Conservation District is also interested in participating as a local agency. They are concerned with the west levees of the Yolo Bypass and particularly those levees creating the Willow Slough Bypass, which is an integral feature of the District's comprehensive drainage program. In addition, it is understood that the Corps will continue to evaluate the levee system for the south Sacramento area, although there appears to be ample freeboard for major flood events based on current hydrologic information.

The preliminary cost estimate for the modified Sacramento Metropolitan Area feasibility study provided by the Corps, is about $300,000. The Board realizes that this is only an estimated cost that will be further defined in the Scope of Study. As nonfederal sponsor, the Board intends to be responsible for providing 50 percent of the feasibility study cost which will be outlined in the Feasibility Cost Sharing Agreement, and will coordinate with the Corps and interested local agencies to meet that requirement.

For further information concerning the project, please call Ray Barsch, General Manager, at (916) 445-9454.

Sincerely,

Wallace McCormack

WALLACE McCORMACK
President

cc: (See attached list.)

Mr. Stephen K. Hall, Vice President
The Reclamation Board
770 E. Shaw Avenue, Suite 216
Fresno, CA 93710

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The Reclamation Board
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Mr. Charles E. Greene, Member
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Mr. Kenneth Ruzich
Reclamation District No. 900
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West Sacramento, CA 95691

Mr. Frank Lang
Reclamation District No. 537
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West Sacramento, CA 95691

Mr. James F. Eagan, General Manager
Yolo County Flood Control and Water
  Conservation District
Rt. 1, Box 1079M
Woodland, California 95695

ATTACHMENT 2

DRAFT FEASIBILITY COST SHARING AGREEMENT

FEASIBILITY COST SHARING AGREEMENT
BETWEEN
THE UNITED STATES OF AMERICA
AND
THE CALIFORNIA STATE RECLAMATION BOARD
FOR
THE SACRAMENTO METROPOLITAN AREA INVESTIGATION, CALIFORNIA

THIS AGREEMENT, entered into this day of , 1989, by and between the United States of America (hereinafter called the "GOVERNMENT"), represented by the Contracting Officer executing this Agreement, and The RECLAMATION BOARD FOR THE STATE OF CALIFORNIA (hereinafter called the "Sponsor").

WITNESSETH, that

Whereas, the Congress has authorized the Corps of Engineers to conduct a study of Northern California Streams pursuant to the Flood Control Act of 1962 (Public Law 87-874, dated October 23, 1962) Title 2, Section 209; and

WHEREAS, the Corps of Engineers has conducted a reconnaissance study of alternative means of providing flood control for the area known as the Sacramento Metropolitan area and has determined that further study in the nature of a "Feasibility Phase Study" (hereinafter called the "Study") for the Sacramento Metropolitan area is required to fulfill the intent of the study authority and to complete the determination of the extent of the Federal interest in a flood control project in this area, and

WHEREAS, the Sponsor has the authority and capability to furnish the cooperation hereinafter set forth and is willing to participate in study cost sharing and financing in accordance with the terms of this agreement; and

WHEREAS, the Sponsor and the Government both understand that entering into this agreement in no way obligates either party to implement a project and that whether a project is supported for authorization and budgeted for implementation depends upon the outcome of this feasibility study and whether the proposed solution is consistent with the Principles and Guidelines and with the budget priorities of the Administration, and that at the present time, favorable budget priority is being assigned to projects providing primarily commercial navigation and flood or storm damage reduction outputs; and

WHEREAS, The Water Resources Development Act of 1986 (P.L. 99-662) specifies the cost sharing requirements applicable to the study;

NOW THEREFORE, the parties agree as follows:

ARTICLE I - DEFINITIONS

For the purposes of this Agreement:

a. The term "Study Cost" shall mean all disbursements by the Government pursuant to this Agreement, whether from Federal appropriations or from funds made available to the Government by the Sponsor, and all Negotiated Costs of work performed by the Sponsor pursuant to this Agreement. Such costs shall include, but not be limited to: labor charges; direct costs; overhead expenses; supervision and administration costs; and contracts with third parties, including termination or suspension charges; and any termination or suspension costs (ordinarily defined as those costs necessary to terminate ongoing contracts or obligations and to properly safeguard the work already accomplished) associated with this Agreement.

b. The term "Study Period" shall mean the time period for conducting the Study, commencing with the issuance of initial Federal feasibility funds following the execution of this Agreement, and ending when the report is submitted to the Office of Management and Budget (OMB) by the Assistant Secretary of the Army for Civil Works (ASA(CW)) for review of consistency with the policies and programs of the President.

c. The term "Negotiated Cost" is the fixed fee for a work item to be accomplished by the sponsor as in-kind services as specified in the Scope of Studies incorporated herein and which is acceptable to both parties.

ARTICLE II - OBLIGATIONS OF PARTIES

a. The Sponsor and the Government, using funds contributed by the Sponsor and appropriated by the Congress, shall expeditiously prosecute and complete the Study, currently estimated to be completed in 16 months from the date of this Agreement, substantially in compliance with Article III herein and in conformity with applicable Federal laws and regulations, the Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies, and mutually acceptable standards of engineering practice.

b. The Government and the Sponsor shall each contribute, in cash and in-kind services, fifty (50) percent of all Study Costs, which total cost is currently estimated to be $400,000, as

specified in Article IV herein; provided, that the Sponsor may, consistent with applicable Federal statutes and regulations, contribute up to 25 percent of the Study Costs as in-kind services; provided further, the Government shall not obligate any cash contribution by the Sponsor toward Study Costs until such cash contribution has actually been made available to it by the Sponsor.

c. The award of any contract with a third party for services in furtherance of this Agreement which obligates Federal appropriations shall be exclusively within the control of the Government. The award of any contract by the Sponsor with a third party for services in furtherance of this Agreement which obligates funds of the Sponsor and does not obligate Federal appropriations shall be exclusively within the control of the Sponsor, but shall be subject to applicable Federal statutes and regulations.

d. The Government and the Sponsor shall each endeavor to assign the necessary resources to provide for the prompt and proper execution of the Study and shall, within the limits of law and regulation, conduct the study with maximum flexibility as directed by the Executive Committee and Study Management Team as established by Article VI, herein.

e. The Government will not continue with the Study if it determines that there is no solution in which there is a Federal interest or which is not in accord with current policies and budget priorities unless the Sponsor wishes to continue under the terms of this Agreement and the Department of Army grants an exception. If a study is discontinued, it shall be concluded according to Article XII, and all data and information shall be made available to both parties.

f. The Sponsor may wish to conclude the Study if it determines that there is no solution in which it has an interest or which is not in accord with its current policies and budget priorities. When such a case exists, the study shall be concluded according to Article XII, and all data and information shall be made available to both parties.

ARTICLE III - SCOPE OF STUDIES

Appendix A, the Scope of Studies, is hereby incorporated into this Agreement. The parties to this Agreement shall substantially comply with the Scope of Studies in prosecuting work on the Study. The following modifications, to be approved by the Executive Committee, shall require an amendment to this Agreement:

a. any modification which increases the total Study Costs by more than 15 percent (see Appendix A, Table 1);

b. any modification in the estimated cost of a Study work item or any obligation for a Study work item, which changes the total cost of that work item by more than 15 percent (see Appendix A, Table 1);

c. any extension of the completion schedule for a Study work item of more than thirty (30) days;

d. any reassignment of work items between the Sponsor and the Government (see Appendix A).

ARTICLE IV - METHOD OF PAYMENT

a. The Government shall endeavor to obtain during each fiscal year the appropriation for that fiscal year at least in the amounts specified in the Scope of Studies incorporated herein. Subject to the enactment of Federal appropriations and the allotment of funds to the Contracting Officer, the Government shall then fund the Study at least in the amounts specified in the Scope of Studies herein.

b. The Sponsor shall endeavor to obtain during each Government fiscal year the cash contribution for that Government fiscal year at least in the amounts specified in the Scope of Studies incorporated herein and, once it has obtained funds for a cash contribution, shall make such funds available to the Government. The Government shall withdraw and disburse funds made available by the Sponsor subject to the provisions of this Agreement.

c. Funds made available by the Sponsor to the Government and not disbursed by the Government within a Government fiscal year shall be carried over and applied to the cash contribution for the succeeding Government fiscal year; provided, that upon study termination the excess cash contribution shall be reimbursed to the Sponsor after a final accounting, subject to the availability of appropriations, as specified in Article XII herein.

d. Should either party fail to obtain funds sufficient to make obligations or cash contributions or to incur Study Costs in accordance with the schedule included in the Scope of Studies incorporated herein, it shall at once notify the Executive Committee established under Article V herein. The Executive Committee shall determine if the Agreement should be amended, suspended or terminated under Article XII herein.

ARTICLE V - MANAGEMENT AND COORDINATION

a. Overall study management shall be the responsibility of an Executive Committee consisting of the District Engineer for the Sacramento District Corps of Engineers, President of the Reclamation Board, and Chief of the Planning Division for the Sacramento District Corps of Engineers. Representatives from the Sponsor's cost sharing partners are also members of the Executive Committee, but their approval or disapproval will be expressed collectively through the vote of the Sponsor.

b. To provide for consistent and effective communication and prosecution of the items in the Scope of Studies, the Government and Sponsor shall appoint staff personnel to serve on a Study Management Team.

c. The Study Management Team will coordinate on all matters relating to prosecution of the Study and compliance with this Agreement, including cost estimates, schedules, prosecution of work elements, financial transactions and recommendations to the Executive Committee for termination, suspension, or amendment of this Agreement.

d. The Study Management Team will prepare quarterly reports on the progress of all work items for the Executive Committee.

ARTICLE VI - DISPUTES

a. The Study Management Team shall endeavor in good faith to negotiate the resolution of conflicts. Any dispute arising under this Agreement which is not disposed of by mutual consent shall be referred to the Executive Committee. The Executive Committee shall resolve such conflicts or determine a mutually agreeable process for reaching resolution or for termination under Article XII herein.

b. Pending final decision of a dispute hereunder, or pending suspension or termination of this Agreement under Article XII herein, the parties hereto shall proceed diligently with the performance of this Agreement.

ARTICLE VII - MAINTENANCE OF RECORDS

The Government and the Sponsor shall keep books, records, documents and other evidence pertaining to study costs and expenses incurred pursuant to this Agreement to the extent and in such detail as will properly reflect total Study costs. The Government and the Sponsor shall maintain such books, records, documents and other evidence for inspection and audit by authorized representatives of the parties to this Agreement. Such material shall remain available for review for a period of three (3) years following the termination of this Agreement.

ARTICLE VIII - RELATIONSHIP OF PARTIES

a. The parties to this Agreement act in an independent capacity in the performance of their respective functions under this Agreement, and neither party is to be considered the officer, agent, or employee of the other.

b. To the extent permitted by applicable law, any reports, documents, data, findings, conclusions, or recommendations pertaining to the Study shall not be released outside the Executive Committee or the Study Management Team; nor shall they be represented as presenting the views of either party unless both Parties shall indicate agreement thereto in writing.

ARTICLE IX - OFFICIALS NOT TO BENEFIT

No member of or delegate to the Congress, or other elected official, shall be admitted to any share or part of this Agreement, or to any benefit that may arise therefrom.

ARTICLE X - FEDERAL AND STATE LAWS

In acting under its rights and obligations hereunder, the local sponsor agrees to comply with all applicable Federal and State laws and regulations, including section 601 of Title VI of the Civil Rights Act of 1964 (Public Law 88-352) and Department of Defense Directive 5500.II issued pursuant thereto and published in Part 300 of Title 32, Code of Federal Regulations, as well as Army Regulation 600-7, entitled "Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army."

ARTICLE XI - COVENANT AGAINST CONTINGENT FEES

The Sponsor warrants that no person or selling agency has been employed or retained to solicit or secure this Agreement upon agreement or understanding for a commission, percentage, brokerage, or contingent fee, excepting bona fide employees or bona fide established commercial or selling agencies maintained by the non-Federal Sponsor for the purpose of securing business. For breach or violation of this warranty, the Government shall have the right to annul this Agreement without liability, or, in its discretion, to add to the Agreement or consideration, or otherwise recover, the full amount of such commission, percentage, brokerage, or contingent fee.

ARTICLE XII - TERMINATION OR SUSPENSION

a. This Agreement shall terminate at the completion of the Study Period; provided, that prior to such time and upon thirty (30) days written notice, either party may terminate or suspend this Agreement without penalty.

b. Within ninety (90) days upon termination of this Agreement, the Study Management Team shall prepare a final accounting of Study Costs, which shall display disbursements by the Government of Federal funds, cash contributions by the Sponsor, and credits for the Negotiated Costs of the Sponsor. Subject to the availability of funds, within thirty (30) days thereafter the Government shall reimburse the Sponsor for the excess, if any, of cash contributions and credits given over fifty (50) percent of total Study Costs. Within thirty (30) days thereafter, the Sponsor shall provide the Government any cash contributions required so that the total Sponsor share equals fifty (50) percent of total Study Costs.

IN WITNESS WHEREOF, the parties hereto have executed this Agreement as of the day and year first above written.

THE UNITED STATES OF AMERICA

BY____________________________
Jack A. Le Cuyer
District Engineer, Sacramento
Corps of Engineers
Contracting Officer

STUDY SPONSOR

BY____________________________
Mr. Wallace McCormack
President, California
Reclamation Board

AND REPRESENTATIVES FROM THE SPONSOR'S COST SHARING PARTNERS

The City of West Sacramento

By____________________________

The County of Yolo

By____________________________

Yolo County Flood Control and Water Conservation District

By____________________________

Reclamation District 537

By____________________________

Reclamation District 811

By____________________________

Reclamation District 900

By____________________________

Reclamation District 2068

By____________________________

ATTACHMENT 3

DRAFT SCOPE OF STUDY

APPENDIX A
SCOPE OF STUDIES
SACRAMENTO METROPOLITAN AREA, CALIFORNIA

PURPOSE AND SCOPE

The purpose of this Scope of Studies is to identify the work items and completion schedules required for the feasibility phase of the Sacramento Metropolitan Area, California. It is also to estimate the cost of the investigation. The result of this phase will be a Feasibility Report that may recommend a water resources plan for implementation. In order to clarify cost-sharing responsibilities, the study obligations of the Corps of Engineers (referenced as "The Government" in Agreement) and the non-Federal Sponsor, The State Reclamation Board (Board), are also identified in accordance with the Water Resources Development Act of 1986 (WRDA of 1986).

DESCRIPTION OF STUDY AREA

The study area includes portions of the Sacramento River Flood Control Project in north-central California. During the reconnaissance phase, the study extended from the Fremont Weir at the confluence of the Feather and Sacramento Rivers downstream to an area just south of Freeport (Plate 1). The urban areas included the City of West Sacramento and south Sacramento. The reconnaissance study showed that alternatives involving the Fremont Weir provided significant flood control benefits for the Natomas area. A decision was made to transfer that portion of the study area relative to Fremont Weir alternatives into the American River Watershed Investigation. The Corps and the Board agreed that this was appropriate since local entities that would benefit most from Fremont Weir alternatives are already providing funds towards the feasibility phase of the American River Watershed Investigation. The remaining study area for the Sacramento Metropolitan Area investigation would include the Sacramento River and the Yolo Bypass from the Sacramento Weir downstream to Freeport. This includes the urban areas of the City of West Sacramento and south Sacramento.

FEASIBILITY STUDY COORDINATION

The feasibility study will be managed by an Executive Committee and a Study Management Team as provided by Article V of the Agreement. The Executive Committee will manage the overall study by (1) maintaining a working knowledge of the feasibility study, (2) assisting in resolving emerging policy issues, (3) assuring that evolving study results and policies are consistent and coordinated, (4) directing the Study Managment Team, and (5) ratifying decisions made by the Study Management Team.

The Study Management Team will consist of a Corps study manager and staff personnel from the non-Federal Sponsor and their cost-sharing partners. It may also include representatives from other Federal, State, and local agencies, interested organizations, and individuals. The Study Management Team will oversee the study to ensure the establishment of desired mutual roles, interests, and study objectives.

PLANS FOR FUTURE STUDY

Reconnaissance studies identified flooding problems within the study area. Based on the results of the reconnaissance phase and input from the sponsor and their cost-sharing partners, alternatives that will be considered in Feasibility studies include the following:

- **Levee improvements for West Sacramento**
- **Levee improvements along the Sacramento River near south Sacramento (the Greenhaven area)**
- **Weir modifications at the Sacramento Weir**

WORK TASKS AND RESPONSIBILITIES

Feasibility studies will concentrate on the above-defined flood control alternatives with a focus on formulating and evaluating the best alternative for implementation. The following is a brief description of the major feasibility phase tasks and the responsibilities for accomplishment of these tasks. At the beginning of each task, the non-initiating agency, either Corps or Sponsor, may review any planned in-kind work or contract of the other for adequacy. At the conclusion of each task, the non-initiating agency may review and approve the results of the work before it is considered complete. Review and assessment of the adequacy of the task will be accomplished by the Study Management Team and its technical staff. The major study tasks and their expected costs are summarized in Table 1.

Public Involvement

Responsibility for this task will be shared between the Corps and the Sponsor. This task primarily consists of coordinating the study scope and results, conducting public meetings, and responding to public inquiries. Also included is preparation of a public involvement plan upon initiation of the feasibility study. This plan will guide activities throughout the studies.

The Corps will take the lead in coordinating meetings on flood control purposes with assistance from the Sponsor as needed. The Corps will provide the Notice of Initiation of the feasibility study, maintain a mailing list, and provide public information summaries toward the end of the study. The Corps

will also assist the Sponsor with its local coordination, prepare and conduct the final public meeting, and provide necessary local, State, and Federal coordination for the study.

The Sponsor will take the lead in coordinating meetings on non-flood control project purposes with special interest groups, local task forces, and local news media, with Corps assistance as needed. The Sponsor will also host the final public meeting and provide the meeting hall.

Institutional Studies

This task will be accomplished by the Corps and primarily consist of determining the financial and legal arrangements required to implement the recommended plan, including methods of financing. A financial capability analysis will examine whether the potential non-Federal Sponsor for construction has the organizational, legal and financial capability to undertake the required financial obligations for implementation of the project after it is authorized for construction by Congress. Studies include determining the political and institutional arrangements of the study area and identifying attitudes and customs regarding the management and use of the resources. The results of the study will be provided in a financial and cost recovery analysis section of the Feasibility Report.

This task will also include estimating alternative repayment options for any incidental project purposes.

Cultural Resources Studies

The cultural resources studies to be performed by the Corps will determine the impacts of the alternative plans on historical, architectural, and archeological resources. A field survey to locate and evaluate cultural sites will be done in accordance with the National Historic Preservation Act of 1966, and a report will be written. There will be coordination with the State Historic Preservation Officer, the National Park Service, and the Advisory Council on Historic Preservation. The Corps will perform the cultural studies, conduct necessary coordination, and evaluate information. A detailed report will be written that outlines significant past and present cultural resources. This report will describe the impacts of each alternative studied in detail and will describe the scope and range of costs for all preservation and mitigation efforts required by such impacts. The preservation of these resources will be considered in more detail for the plan recommended for construction in any advanced planning for the project.

Environmental Studies

This task includes collecting environmental data that define existing and future conditions. The alternatives studied in detail will be evaluated, and the environmental impacts and mitigation features will be identified. Requirements of Section 7 of the Endangered Species Act will be completed during the feasibility study, including a biological assessment and formal consultation with the U.S. Fish and Wildlife Service (FSW) and the California Department of Fish and Game if necessary.

The Environmental Information Paper prepared in the reconnaissance phase will be expanded into a Draft and Final Environmental Impact Statement that will evaluate the environmental effects of the alternative plans. This report will be coordinated with Federal, State, and local governments and agencies as well as interested groups and individuals.

Mitigation features for fish and wildlife and other affected resources will be refined and a monitoring program developed. Any land required for mitigation will be identified. A plan will be developed for fish and wildlife resources mitigation, for enhancement if sponsored by non-Federal agencies and for their management in connection with the project. A monitoring plan will be developed to record the success of the mitigation measures.

A Section 404b(1) evaluation of water quality impacts will be accomplished and coordinated with State and Federal water quality agencies to ensure adequate consideration has been given to water quality and acquire water quality certification.

Fish & Wildlife Studies

This task includes studies conducted by the FWS in support of the above-mentioned Environmental Studies by agreement with the Corps as required by the Fish and Wildlife Coordination Act. The FWS will form an interagency team to conduct a Habitat Evaluation Procedure (HEP) and other similar studies (e.g., instream flow incremental methodology) to define impacts and determine the amount of required mitigation. In these studies, baseline conditions and project-induced environmental effects will be evaluated, and types and amounts of mitigation for habitat losses will be determined. This task also includes management of the FWS work agreement. A FWS Coordination Act Report will be prepared that will refine environmental effects of the selected alternative, summarize the HEP and other studies findings, and incrementally analyze alternative mitigation strategies acceptable to the FWS for all alternatives studied in detail.

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Economic Studies

This task consists of evaluating flood damages, flood damage reduction benefits, and potential benefits associated with other incidental purposes.

The amount of flood-damageable property estimated in the reconnaissance report will be supplemented with an inventory of the flood plain. A computer model that helps define the relationships between damageable property and flood events will be refined to develop feasibility level estimates of average annual flood damages that occur with and without the proposed plans. Transportation information, emergency cost savings, and impact of the recommended plan on Federal Emergency Management Agency requirements will be included in this estimate. An estimate of foundation heights and structural characteristics will be included in the study along with a specific land use analysis.

These studies will assist in measuring flood control benefits and sizing proposed projects. An economic report will be provided for inclusion in the technical documentation for the feasibility study.

Hydrology and Related Studies

This work item includes model simulation studies for flood control; flow frequency relationships; wind setup and wave run-up; and documentation of the results in a hydrology report. This evaluation will estimate existing and expected without-project condition hydrology in the study area.

Design and Cost Estimates

This task will be conducted by the Corps. It will include design and cost estimates of all alternative plans, structures, relocations, and estimates of average annual operations, maintenance, and replacement costs.

This task includes an office report to document the design work and cost estimates.

Real Estate Studies

This task will be performed by the Corps. It will include a preliminary appraisal of land costs and damages required for economic evaluations of alternative plans. Determination of lands, easements, and rights-of-way for the recommended plan will also be included.

Study Management

This task will be accomplished by the Corps in coordination with the Sponsor. It includes all activities related to study management, such as study scheduling, providing detailed information for the work done by others, monitoring and modifying assigned work items as required, reviewing results and reports provided by the technical support staff, and coordinating with other Corps offices. Budget preparation, correspondence, interorganization coordination, and point-of-contact responsibilities are also part of the management program. Periodic meetings will be held between the Corps and the Sponsor to report on the status of the study and possible in-kind services, and monthly status reports and financial monitoring will be provided by the Corps. Assistance and technical studies and technical coordination will also be provided. The general direction and condition of the study will be managed and monitored at all times.

Study management will ensure that all required tasks and coordination are performed. The study management structure developed during the reconnaissance phase will continue into the feasibility phase and include coordination efforts associated with the Study Management Team and Executive Committee.

Plan Formulation

This task includes reviewing and refining the plans selected for study during the feasibility phase and other plans formulated to date, and developing required alternatives such as no-action and nonstructural plans. This task also includes identifying the NED plan, considering environmental impacts and the views of the public, and formulating mitigation measures. The costs and benefits associated with each plan will be determined, and trade-offs required to select the recommended plan for implementation will be identified.

The annual and periodic activities and responsibilities for operating and maintaining the completed project will be described and closely coordinated with other requirements (e.g., cost estimates and environmental monitoring). The general magnitude of these activities will be described for all alternatives studied in detail; however, more detail will be provided for the alternative(s) recommended for implementation. All requirements of 33 CFR 208 and other Federal regulations specifying operation and maintenance requirements will be clearly described so that the Sponsor's future duties will be known.

This task will be primarily a Federal responsibility.

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This task will be primarily a Federal responsibility.

Report Preparation

This task will be the responsibility of the Corps in coordination with the Sponsor, and the work includes assembling pertinent data, writing, editing, typing, drafting, reviewing, revising, reproducing, and distributing the draft and final feasibility reports, Environmental Impact Statements and related technical documents.

This task also includes work items necessary to support the review process from the signing of the feasibility report to the request by the Assistant Secretary of the Army for Civil Works (ASA(CW)) to the Office of Management and the Budget (OMB) for the views of the administration. These items could also include answering comments, attending meetings of the Board of Engineers for River and Harbors, and revising the report.

Review Contingency

This item covers possible requirements for additional rewriting, reformulation, or documentation as a result of Washington-level review. Any costs that are incurred after the end of the feasibility phase (i.e., submittal of the report to the OMB by the ASA) but prior to Preconstruction Engineering and Design will be 100 percent Federal.

FEASIBILITY STUDY COSTS ESTIMATE

The study cost estimate for the feasibility phase is $400,000 (see Table 1). All feasibility phase study costs are required to be cost shared between the Corps and the Sponsor on a 50-50 basis. Further, the Sponsor will provide, as a minimum, half of its share as a cash contribution. Table 1 outlines tasks to be performed, estimated cost of each task, and study obligations for the Corps and Sponsor.

The cost estimate for the feasibility study will be separated into fiscal years and quarters. Table 2 outlines the costs for each quarterly period during the feasibility study. The Corps will provide periodic reports to the Sponsor, which would include "Selective F&A Data Base Record, Form 666." The Sponsor will provide the Corps, on a quarterly basis, similar finance and accounting data that would record the work-in-kind efforts by the Sponsor. The value of the in-kind services will be based on the equivalent government cost.

FEASIBILITY STUDY SCHEDULE

The final Feasibility Report and EIS are scheduled to be submitted to the South Pacific Division in about 16 months after the signing of the FCSA. The schedule of major tasks and work items leading to this submission (assuming adequate funds are

available by 1 July 1989) are indicated in Plate 2. It is expected that processing the Feasibility Report (Washington level review), terminating with provision of the report to the OMB, will take up to an additional 7 months (total study period of 23 months).

COORDINATION MECHANISM BETWEEN THE CORPS AND SPONSOR

The Executive Committee is scheduled to meet, at a minimum, at the signing of the FCSA, at the Public Meeting, and at the concluding Issue Resolution Conference (IRC). The Committee will also meet periodically to discuss the project status and to handle changes in study scope that would result in an increase in total study cost or major changes in study direction, and at additional IRCs, if necessary. The Study Management Team will meet about every six weeks.

Financial coordination will include quarterly financial statements composed of expenditures and obligations. The Corps will also provide quarterly reports to the Sponsor, which would include "Selective F&A Data Base Record, Form 666." The Sponsor will provide the Corps, on a quarterly basis, similar finance and accounting data that will record cash expenditures and work-in-kind efforts by the Sponsor and the Sponsor's associates. Cost-sharing cash payments will be made to the Corps on or about June 1 (1989), August 1 (1989), December 1 (1989) and March 1 (1990). A final reconciliation of the cost-sharing cash payment will be made at the conclusion of the study. The Corps will also furnish to the Sponsor a monthly progress report, detailing the status of each study task.

TABLE 1
FEASIBILITY STUDY COST ESTIMATE
($1,000)

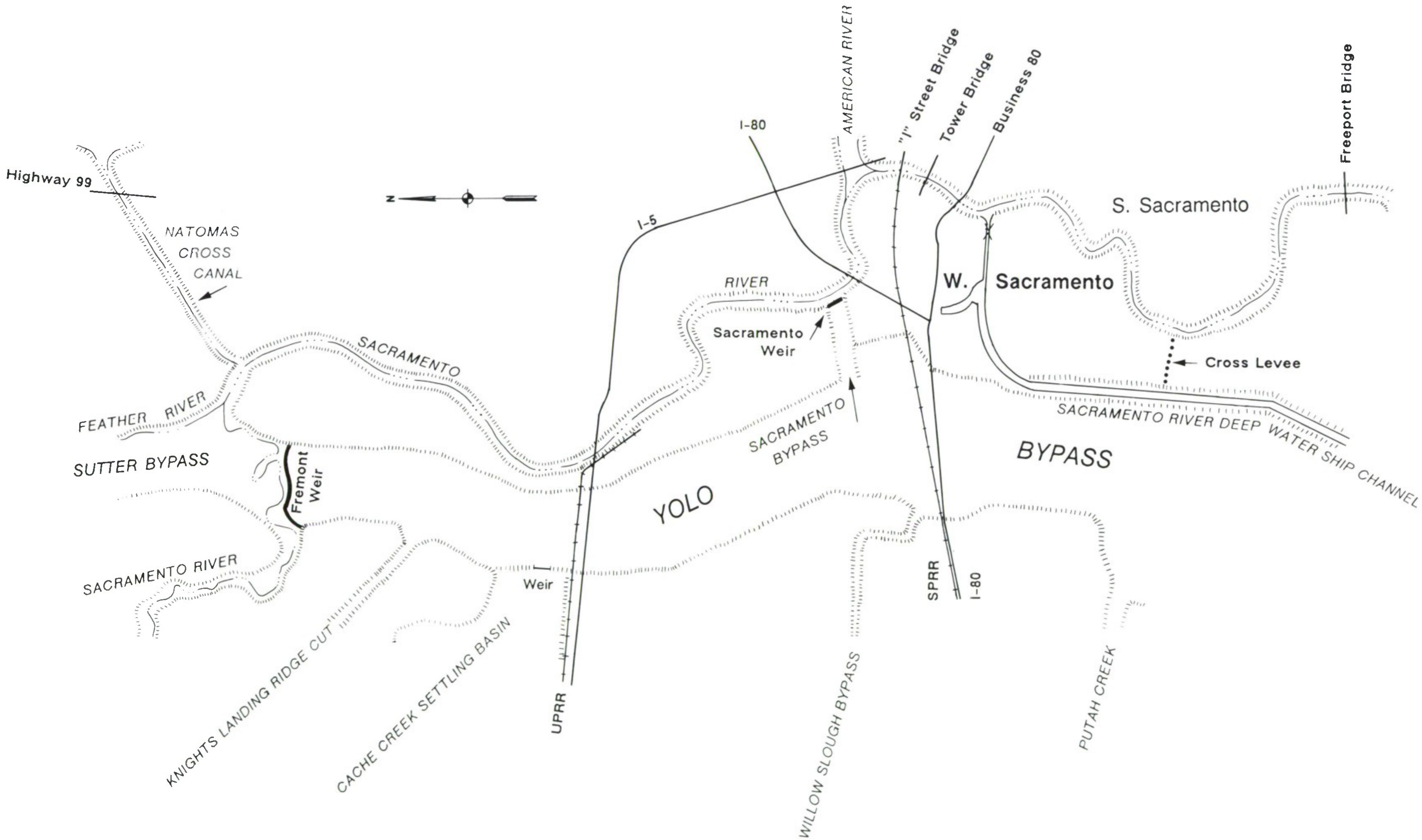
TASK	CORPS	SPONSOR	CONTRACT	TOTAL
PUBLIC INVOLVEMENT	5	3		8
INSTITUTIONAL STUDIES	2			2
CULTURAL RESOURCES	10			10
ENVIRONMENTAL STUDIES	50			50
FISH & WILDLIFE STUDIES			30	30
ECONOMIC STUDIES	47			47
HYDROLOGY STUDIES	40			40
DESIGNS & COSTS	75			75
REAL ESTATE STUDIES	15			15
STUDY MANAGEMENT	60	3		63
PLAN FORMULATION	18			18
REPORT PREPARATION	20	2		22
REVIEW & CONTINGENCY	18	2		20
TOTAL	360	10	30	400
CONTRACTS	30	0		
SUBTOTAL	390	10		
CASH ADJUSTMENT	-190	190		
50% OF STUDY COST	200	200		

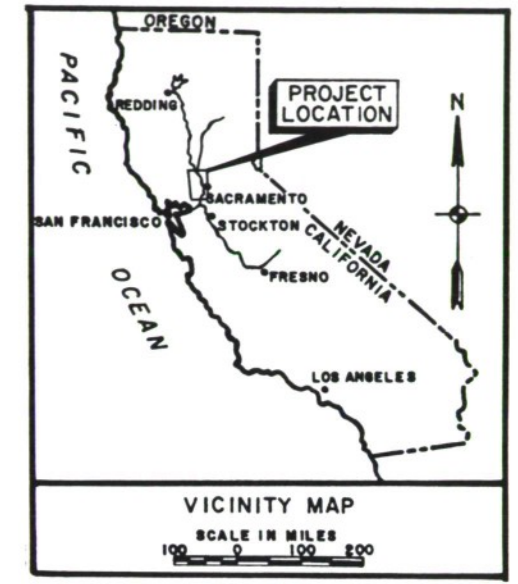
TABLE 2
FEASIBILITY COST BY QUARTER
(in $1,000)

Task	1989		1990				1991				Task Total
	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th	
Public Involvement 1/	1	2			2	2	1				8
Institutional Studies			.25	1.50	.25						2
Cultural Resources	1	4	4	1							10
Environmental Studies	5	13	13	14	5						50
Fish & Wildlife Studies (C) 2/	3	12	12	3							30
Economic Studies	5	18	18	6							47
Hydrology Studies	10	30									40
Designs & Costs		15	45	15							75
Real Estate Studies			15								15
Study Management	4	11	11	11	11	12	3				63
Plan Formulation	1	5	5	5	2						18
Report Preparation			5	5	5	5	2				22
Review Contingency					4	4	4	4	2	2	20
Total											
Labor	27	98	116.25	58.50	29.25	23	10	4	2	2	370
Contracts	3	12	12	3	0	0	0	0	0	0	30
Total	30	110	128.25	61.50	29.25	23	10	4	2	2	400
Federal	15	55	64.13	30.75	14.63	11.50	5	2	1	1	200
Non-Fed											
In-Kind	0	1.50	1	1	2.40	2.90	.40	.40	.20	.20	10
Cash	15	53.50	63.13	29.75	12.23	8.60	4.60	1.60	.80	.80	190
Year Total	1989 =	140			1990 =	242			1991 =	18	
Federal		70				121				9	
Non-Fed											
In-Kind		1.50				7.30				1.20	
Cash		68.50				113.70				7.80	

1/ Except where noted, costs are for total labor and include an allowance for indirect and overhead

2/ C = Contract





LEGEND

FEDERAL LEVEES

PRIVATE LEVEES

NOT TO SCALE

SACRAMENTO METROPOLITAN AREA
CALIFORNIA

STUDY AREA

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
DECEMBER 1988

PLATE 1

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Schedule Name:   SACRAMENTO METROPOLITAN AREA FEASIBILITY STUDY SCHEDULE
Project Manager: DAVE GUNDLACH
As of date:      26-Apr-89 10:32am    Schedule File: A:SACMETRO


                                  89                90                                    91
                                  Jun Jul Aug  Sep Oct Nov Dec Jan Feb Mar Apr May  Jun Jul Aug  Sep Oct Nov Dec Jan Feb Mar Apr  May Jun Jul  Aug Sep Oct  NovDec
                           Status 1   3   1    1   2   1   1   2   1   1   2   1    1   2   1    4   1   1   3   2   1   1   1    1   3   1    1   3   1    1 2

BEGIN FEASIBILITY PH          C M  .   .    .   .   .   .   .   .   .   .   .    .   .   .    .   .   .   .   .   .   .   .    .   .   .    .   .   .    . .
Hydrology Studies             C ==================  .   .   .   .   .   .   .    .   .   .    .   .   .   .   .   .   .   .    .   .   .    .   .   .    . .
Cultural Resources            C ==================================  .   .   .    .   .   .    .   .   .   .   .   .   .   .    .   .   .    .   .   .    . .
Economic Studies              C ==================================  .   .   .    .   .   .    .   .   .   .   .   .   .   .    .   .   .    .   .   .    . .
Fish and Wildlife St          C ==================================  .   .   .    .   .   .    .   .   .   .   .   .   .   .    .   .   .    .   .   .    . .
Plan Formulation                ==========================================----   .   .   .    .   .   .   .   .   .   .   .    .   .   .    .   .   .    . .
Environmental Studie          C ==============================================   .   .   .    .   .   .   .   .   .   .   .    .   .   .    .   .   .    . .
Public Involvement            C =======================================================================.  .   .   .   .   .   .    .   .   .    .   .   .    . .
Study Management              C =======================================================================.  .   .   .   .   .   .    .   .   .    .   .   .    . .
Public Meeting 1             p      . M .    .   .   .   .   .   .   .   .   .    .   .   .    .   .   .   .   .   .   .   .    .   .   .    .   .   .    . .
Designs & Costs              pC     1-Sep-89 =====================  .   .   .    .   .   .    .   .   .   .   .   .   .   .    .   .   .    .   .   .    . .
CONFERENCE 1                        .   2-Oct-89 M  .   .   .   .   .   .   .    .   .   .    .   .   .   .   .   .   .   .    .   .   .    .   .   .    . .
Report Preparation           pC     .   2-Oct-89 ======================================================.  .   .   .   .   .   .    .   .   .    .   .   .    . .
Real Estate Studies          p      .   2-Oct-89 =============----  .   .   .    .   .   .    .   .   .   .   .   .   .   .    .   .   .    .   .   .    . .
Institutional Studie         p      .   .    .  1-Dec-89 =====================    .   .   .    .   .   .   .   .   .   .   .    .   .   .    .   .   .    . .
CONFERENCE 2                        .   .    .   .   .  2-Feb-90 M  .   .   .    .   .   .    .   .   .   .   .   .   .   .    .   .   .    .   .   .    . .
DRAFT REPORT TO DIV           C     .   .    .   .   .   .   .   .  1-May-90 M   .   .   .    .   .   .   .   .   .   .   .    .   .   .    .   .   .    . .
Review Contingency            C     .   .    .   .   .   .   .   .  1-May-90 =================================================================.   .   .    . .
ISSUES RESOLUTION CO         p      .   .    .   .   .   .   .   .   .  13-Jun-90.M  .   .    .   .   .   .   .   .   .   .    .   .   .    .   .   .    . .
Public Meeting 2             p      .   .    .   .   .   .   .   .   .   .  3-Jul-90 M   .    .   .   .   .   .   .   .   .    .   .   .    .   .   .    . .
FINAL RPT TO DIV OFF                .   .    .   .   .   .   .   .   .   .   .    .   .   . 29-Oct-90 M.  .   .   .   .   .    .   .   .    .   .   .    . .
END FEASIBILITY PHAS          C     .   .    .   .   .   .   .   .   .   .   .    .   .   .    .   .   .   .   .   .   .   .    . 1-Aug-91 M   .   .    . .

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D Done                   === Task          - Slack time (==---), or
C Critical               +++ Started task    Resource delay (---==)
R Resource conflict        M Milestone     > Conflict
p Partial dependency
Scale: Each character equals 1 week
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ATTACHMENT 4

ENVIRONMENTAL INFORMATION PAPER

ENVIRONMENTAL INFORMATION PAPER

SACRAMENTO METROPOLITAN AREA, CALIFORNIA
INTERIM INVESTIGATION

Table of Contents

1.0 Introduction

The Sacramento District is conducting a reconnaissance study of flood control alternatives in the Sacramento area. The study will identify the level of flood protection provided by the existing projects and determine the need for additional protection appropriate for the Sacramento area. Preliminary alternatives have been developed that address this need. The reconnaissance study is expected to be completed by February 1989. This environmental information paper (EIP) describes current environmental conditions and potential effects of the proposed alternatives. This EIP also identifies resources that will require additional study if one or more alternatives are selected for feasibility level studies.

2.0 Scope of Analysis

This EIP will serve as a baseline for subsequent planning efforts and impact assessments. Included in this analysis are: the environmental setting of the project area, vegetation, fisheries and wildlife communities, endangered and threatened species, and cultural resources.

3.0 Location

The study area is located within the Central Valley of California in Yolo and Sacramento Counties. The Sacramento River forms the northern and eastern boundaries of the study area. The study area begins just upstream of the Fremont Weir at the confluence of the Sacramento and Feather Rivers and extends downstream to an area just south of Freeport. The west levee of the Yolo Bypass forms the western boundary of the study area. North of the confluence of the Sacramento and American Rivers, the study area includes the west levee of the Sacramento River. South of this confluence, the study area includes both east and west levees of the Sacramento River (see Figure 1). The study area has been divided into three reaches based on the location of potential alternatives: 1) the Yolo Bypass, 2) the Sacramento Bypass, and 3) West Sacramento.

1) The Yolo Bypass extends from the Fremont Weir at the northern end, conducts floodflows west around the City of Sacramento, and empties into the Delta at the southern end. The study area is the northern portion of the bypass from the Fremont Weir south to near Putah Creek.

2) The Sacramento Bypass begins at the Sacramento Weir and extends approximately 2 miles west before it joins the Yolo Bypass. The study area includes the entire Sacramento Bypass.

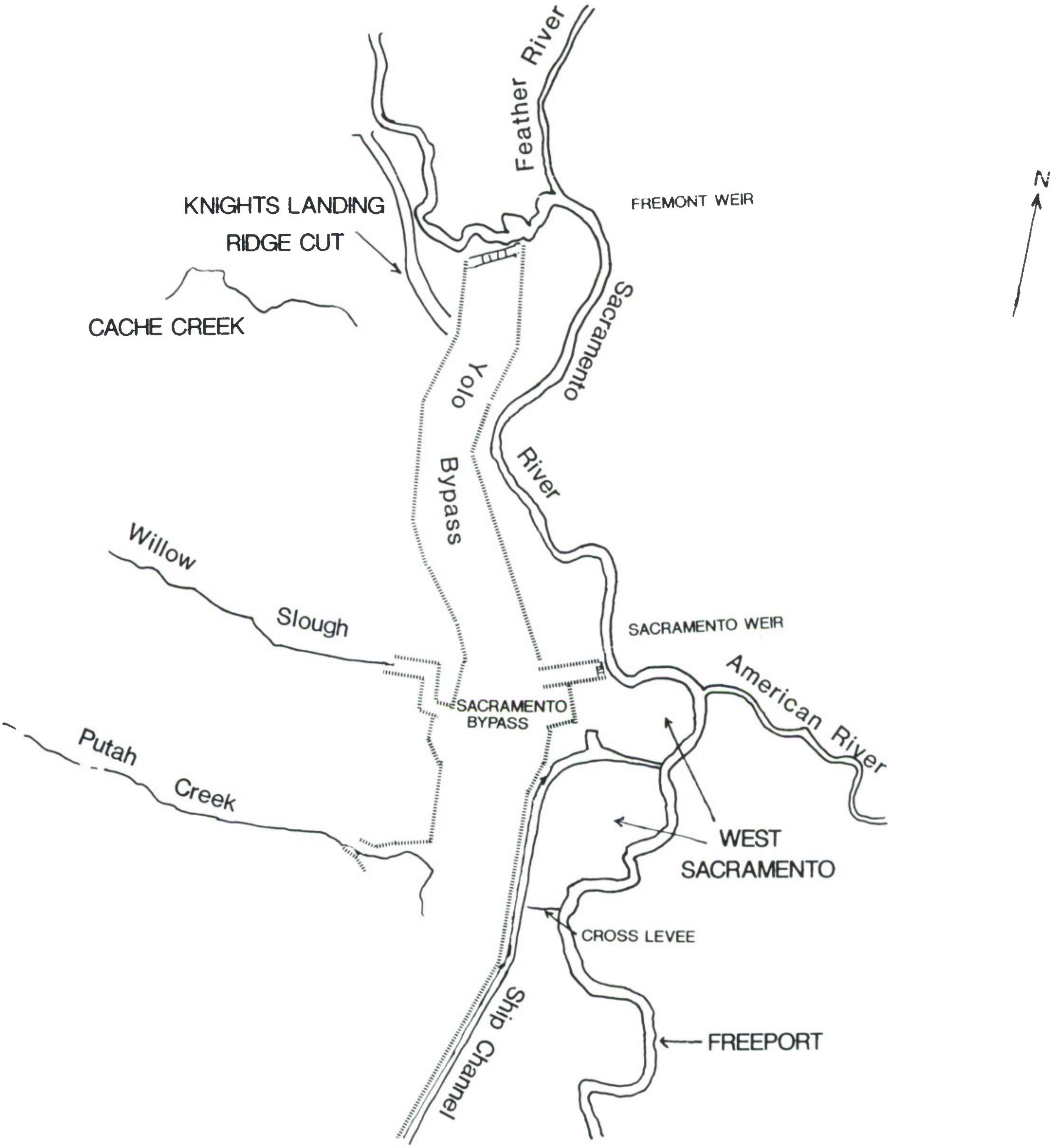

Figure 1 Study Area Location

3) The West Sacramento area is bordered by the Sacramento Bypass on the north, the Yolo Bypass on the west, a cross levee to the south, and the Sacramento River to the east. This area includes a portion of the Sacramento River Deep Water Ship Channel (Ship Channel) and associated port facilities.

4.0 Problems and Opportunities

The study area includes portions of the Sacramento River Flood Control Project (SRFCP) that was authorized by the Flood Control Act of 1917. The SRFCP is a comprehensive system of levees, overflow weirs, drainage pumping plants, and flood bypass channels, extending along the Sacramento River from Collinsville upstream to Ord Bend and along the lower reaches of principal tributaries. The Yolo and Sacramento Bypasses are a part of this project and are maintained by the State of California, Department of Water Resources.

The recent flood event in February of 1986 raised concern over the continued effectiveness of the flood control system in the Sacramento area. Hydraulic evaluations indicate that the level of flood protection is not as high as previously estimated. In some areas it is less than 100-year level of protection. Because significant development has occurred in the study area since construction of the bypass system, levee failure and potential deep depths of flooding could result in catastrophic losses of property and lives.

Additional Corps studies that address flooding problems in the Sacramento area include the American River Watershed Investigation and the Sacramento River Flood Control System Evaluation. In addition, the Sacramento River Bank Protection Project is an existing authorized project providing for the construction of bank protection to maintain the integrity of the existing levees and flood control facilities of the SRFCP. A study authorized for future investigation is the Flood Damage Prevention Study for the Yuba River Basin. This study will address flooding problems in the Yuba City-Marysville area north and east of the Sacramento Metropolitan area.

5.0 Alternatives

Formulation of alternatives is preliminary and could be modified in the planning process based on public input, study results, and local sponsorship. In addition to the six alternatives described below, preliminary analysis also included non-structural alternatives of removing existing structures now located waterside of the Sacramento River levee, and prohibiting future construction waterside of the levee. Based on current regulations governing construction within this river reach, these alternatives do not have a significant impact on levels of flood protection within the study area during major flood events. For this reason they were not considered in subsequent detailed

evaluations. Another alternative not considered for further evaluation was that of dredging the bottom of the Sacramento River to increase flow conveyance. This alternative would not provide a permanent solution and could require a regular commitment to dredge in the future. Because of the uncertainties involved in determining aggradation following dredging, and the ability to conduct maintenance dredging activities in the future, this measure was deleted from further consideration. In addition, because of the potential significant flood damage and loss of life, a permanent solution is considered necessary.

The six alternatives that are being evaluated are listed below. In addition, the no action alternative is included as the baseline condition. All other alternatives are compared to the no action alternative. The level of flood protection provided by each alternative is also listed below. The levels of flood protection discussed under each alternative are based on reconnaissance level information. As hydrology and hydraulic studies continue in the feasibility phase, levels of flood protection will be further refined.

A. <u>No Action</u>. This alternative would consist of maintaining existing conditions. There would be no Federal participation in flood control alternatives for increased levels of flood protection. In addition, as future development occurs within and upstream of the study area, the level of protection provided by the existing project would decrease. Under present conditions excess flood waters are diverted around the cities of Sacramento and West Sacramento and empty into the Delta. Floodflows are diverted into the Yolo Bypass through the Fremont Weir and into the Sacramento Bypass through the Sacramento Weir. The existing level of flood protection in the project area varies by reach. The west levee of the Sacramento River north of the Sacramento Bypass has 75 year protection, the east levee of the Sacramento River north of the American River has 90 year protection. The north levee of the Sacramento Bypass has 80 year protection and the south levee has 90 year protection. The west levee of the Sacramento River south of the Sacramento Bypass provides 90 year protection to the West Sacramento area, and the east levee provides 200 year protection. (Each level of flood protection assumes that levee embankments are structurally stable at existing design conditions.)

B. <u>Modify Fremont Weir and Yolo Bypass.</u> This alternative could provide up to 190 year protection to the west levee of the Sacramento River north of the Sacramento Bypass. Between the Natomas Cross Canal and the American River this alternative could provide up to 200 year protection to the east levee of the Sacramento River. This alternative would be implemented in one of the following methods:

1) Set back the east levee of the Yolo Bypass in a landward direction from the Fremont Weir south for approximately 15,000 feet. The weir would be extended on the east side.

3) The West Sacramento area is bordered by the Sacramento Bypass on the north, the Yolo Bypass on the west, a cross levee to the south, and the Sacramento River to the east. This area includes a portion of the Sacramento River Deep Water Ship Channel (Ship Channel) and associated port facilities.

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B. Modify Fremont Weir and Yolo Bypass. This alternative could provide up to 190 year protection to the west levee of the Sacramento River north of the Sacramento Bypass. Between the Natomas Cross Canal and the American River this alternative could provide up to 200 year protection to the east levee of the Sacramento River. This alternative would be implemented in one of the following methods:

1) Set back the east levee of the Yolo Bypass in a landward direction from the Fremont Weir south for approximately 15,000 feet. The weir would be extended on the east side.

Two distances of levee setback are being considered, 500 feet and 1,500 feet. Material needed for the new levee construction would be obtained from the existing levee embankment and borrow from within the Yolo Bypass.

2) Lower Fremont Weir by removing one foot of concrete from the top of the weir and reforming the crown. Sediment removal upstream and downstream of the weir may also be necessary in conjunction with this alternative.

C. <u>Modify Sacramento Weir and Bypass.</u> This alternative could provide up to 200 year protection to the west levee of the Sacramento River between the Sacramento Weir and the cross levee. Along the east levee of the Sacramento River downstream of the American River protection would be equal to or greater than 200 years. This alternative would be implemented in one of the following methods:

1) Set back the north levee of the Sacramento Bypass in a landward direction. Two distances of levee setback are being considered, 500 feet and 1,500 feet. The weir would be extended the appropriate length on the north side. Material needed for new levee construction would be obtained from the existing levee embankment and borrow from within the Sacramento Bypass.

2) Remove the gates on the Sacramento Weir.

3) Lower the crest of the weir by 0.5 or 1 foot. Excavation of sediment upstream and downstream of the weir may be necessary in conjunction with this alternative.

D. <u>Divert Floodwaters into the Sacramento River Deep Water Ship Channel.</u> This alternative entails diverting a portion of the floodwaters in the Yolo Bypass and/or the Sacramento River into the Ship Channel via a siphon or overflow weirs. This alternative would include constructing new levees adjacent to the port facilities and diversion facilities to connect the Sacramento River and/or the Yolo Bypass to the Ship Channel. Flood protection provided by this alternative was not calculated.

E. <u>Modify Levees Around West Sacramento.</u> This alternative would consist of improving portions of the levees around the City of West Sacramento to increase the level of flood protection to that community. This would include raising the levee near Raley's Landing on the west side of the Sacramento River in a landward direction, and raising the east and west sides of the Yolo Bypass in the vicinity of West Sacramento. The east levee of the Yolo Bypass would be raised from the south levee of the Sacramento Bypass to the cross levee where Jefferson Boulevard begins to parallel the Ship Channel. (Both sides of the Sacramento Bypass would be included.) The west levee of the Yolo Bypass would be raised from about 9,000 feet above the north levee of Willow Slough to the south levee of Putah Creek. This

could also include up to 10,000 feet of levee modifications on both Willow Slough Bypass and Putah Creek. All construction and widening would be in a landward direction. Levees would be modified to provide either 100 year or 200 year flood protection to the West Sacramento area.

F. Remove Flow Constrictions from Yolo Bypass. This alternative would consist of replacing highway and railroad embankments with bridge structures to improve flow conveyance and reduce flood stages in the area of Yolo Bypass adjacent to West Sacramento. This alternative would provide 180 year protection along the south levee of the Sacramento Bypass and along the east levee of the Yolo Bypass between the Sacramento Bypass and the Ship Channel. Along the north levee of the Sacramento Bypass flood protection would be increased to 150 years. Along the east levee of the Yolo Bypass north of the Sacramento Bypass flood protection would be increased to 95 years.

G. Combination. This alternative would consist of using various combinations of the above alternatives.

6.0 Environmental Setting

The study area is approximately 150 square miles in size. The Yolo Bypass contains approximately 40,000 acres (within the study area), the Sacramento Bypass 600 acres, and the West Sacramento area 13,000 acres. Land within the bypasses is privately owned. The State of California has purchased flowage easements over this land. In order to prepare a concise discussion of environmental impacts, the discussion of resources is divided into sections. Resources not likely to be significantly affected by the alternatives under study are discussed in this section. Resources that are likely to be significantly affected are discussed in sections 7.0 through 11.0.

6.1 Geology. The study area is located in the southern part of the Sacramento Valley, which is geologically part of the Great Valley geomorphic province of California. The broad Valley was filled with erosion debris that originated in the surrounding mountain areas. Geologic formations underlying the Sacramento Valley include igneous, metamorphic and sedimentary rocks.

6.2 Soils. Most soils found within the study area are recent alluvial. They consist of unconsolidated deposits of clay, silt, and sand and occur as flood plain deposits. This soil type tends to be very young because fresh alluvium is deposited (particularly within the bypasses) with each floodflow. Soils of this type are highly suited for a wide range of agricultural uses.

6.3 Climate. The Sacramento area has a Mediterranean type of climate characterized by hot, dry summers with little precipitation and mild, rainy winters. The bulk of the

precipitation occurs during the months of November to April. Precipitation in the Sacramento area averages 16 to 17 inches per year.

Local meteorological conditions are a product of the topography of the Sacramento Valley. Wind directions reflect the channeling effect of the mountain ranges that surround the valley. Prevailing winds at West Sacramento are from the south and west. Airflow passes through the Carquinez Strait, bringing cool southerly winds from the ocean in the summer and rainstorms in the winter.

6.4 Air Quality. The study area lies within the Sacramento Valley Air Basin. The major urban centers in the vicinity are the Cities of West Sacramento and Sacramento. The study area is located in Yolo County and is under the jurisdiction of the Yolo-Solano Air Pollution Control District (APCD). The Yolo-Solano APCD operates several monitoring stations that measure ozone, carbon monoxide, suspended particulate matter, nitrogen dioxide, and sulphur dioxide.

Pollutant sources in the Sacramento Valley are classified as urban. Federal air quality standards for ozone are being exceeded several times per year. Contributors to the regional ozone problem include motor vehicle emissions, pesticide use and non-highway mobile sources (boating, off-road vehicles and aircraft operation). As the West Sacramento area continues to develop, air quality problems associated with the increase of motor vehicle emissions may occur.

Air quality impacts associated with the proposed alternatives are expected to be short term construction impacts. No long term impacts to air quality from the project alternatives are expected.

6.5 Water Quality. Water quality of the Sacramento River is considered good, although it is affected by runoff from developed areas and upstream agricultural uses. During the spring and fall, irrigation tailwaters are discharged into drainage canals that flow into the river. In the winter, runoff flows over these same areas. These flows are more turbid and bring in pesticides and herbicides.

Water in the Ship Channel near the Port of Sacramento (Port) exhibits similar physical characteristics although the level of total dissolved solids at the turning basin is somewhat higher than is found in the Sacramento River. This occurs because insufficient water moves through the locks to flush the upper portion of the channel. Other water quality parameters do not differ significantly.

None of the proposed alternatives involve work in either the Sacramento River or the Ship Channel. The proposed alternatives are not expected to affect the water quality of the Sacramento River.

6.6 Land Use.

A. Yolo Bypass. Land in the northern portion of the bypass near the Fremont Weir is maintained in a relatively natural state. The area north of the weir is designated as a State of California Wildlife Management Area. Deposited material is removed as required to maintain the flood control operations in a manner so as to minimize impact to vegetation. The land just south of the weir is managed as a private refuge. As such, neither of these areas is farmed nor hunted, and cattle grazing takes place only in the area south of the weir. Along the rest of the Yolo Bypass south to Putah Creek, land is used for farming. Typical crops include rice, corn and safflower.

B. Sacramento Bypass. The central portion of this bypass is not farmed. Because of high velocities during floodflows, the eastern end is generally scoured and somewhat devoid of vegetation. The remainder of the bypass is kept clear of heavy vegetation as part of project maintenance. The bypass has been designated by the State of California as the Sacramento Bypass Wildlife Area and is managed for wildlife habitat within constraints of the area's primary purpose, which is flood control. Toe drains waterward of the north and south levees contain riparian scrub and mature riparian vegetation. The landside of the north levee is farmed. The Highway Patrol Academy is located on the landside of the southern levee.

C. West Sacramento. The West Sacramento area contains a mixture of residential, commercial, industrial, and agricultural uses. The study area includes the City of West Sacramento which is rapidly urbanizing. The Port is the City's primary industrial district. The Port is a major shipping installation and is the focus of the industrial activity. Land use adjacent to the west Sacramento River levee is primarily residential and open space. Land use along the western and southern boundary is made up primarily of industrial and agricultural uses. Much of this agricultural land is expected to be converted to residential, commercial and industrial uses in the near future. Proposed or committed projects include the Lighthouse Marina, Raley's Landing, Southport Industrial Park, and Newport Specific Plan.

6.7 Socioeconomic Conditions. Within the study area, the city of West Sacramento is the major urban center. No residential, commercial or industrial development is allowed in either of the flood bypass areas. The current population of West Sacramento is approximately 27,500 and is projected to grow to 32,170 by 2000 and 36,102 by 2010.

In 1980, the median household income in West Sacramento was $12,794, and the unemployment rate was around 7.5 percent. In 1986, the median housing value was $70,000. Employment types includes wholesale and retail trade, manufacturing, professional and agricultural.

6.8 Recreation and Esthetics. The Sacramento River supports a variety of recreational activities including fishing, boating, water skiing, hiking and picnicking. There is limited public land adjacent to the Sacramento River. There are a number of recreational facilities along the river that are mostly oriented to fishing and boating. In the study area there are approximately 20 marinas along the Sacramento River. The Sacramento River supports large runs of anadromous fishes, mainly salmon, striped bass, steelhead trout and American shad. The sport fishery that these runs provide is probably the largest single recreational resource of the river. Visual resources of the Sacramento River are varied. Within the study area the river is fairly slow moving and confined between the closely adjacent levees. Strips of riparian forest are found in this area although much of the riparian vegetation once found along the riverbank has been lost. The project alternatives are not likely to affect the recreational or visual characteristics of the Sacramento River.

Along both the Yolo and Sacramento Bypasses recreational activities are limited to fishing for warm water resident species such as catfish and carp. Visual resources in these areas are limited to the riparian vegetation found in toe drains waterside of the levees. Project alternatives could require the removal of some riparian vegetation. This vegetation would be replaced through mitigation. The recreational and visual resources of this area are not likely to be impacted except for short-term construction impacts.

7.0 Vegetation in the study area includes the following types of habitat: valley grassland, valley oak woodland, willow scrub, mixed riparian forest, and freshwater marsh.

7.1 Affected Environment - Yolo Bypass. The Sacramento River forms the northern boundary of this section and predominantly supports mixed riparian forest and riparian scrub. This vegetation forms a narrow, linear band adjacent to the river. In the immediate vicinity of the Fremont Weir, mixed riparian forest and riparian scrub are found near the Sacramento River.

At the northern end of the Yolo Bypass emergent marsh, valley grassland, valley oak woodland, riparian forest, and riparian scrub are found. The riverside of the Fremont Weir supports numerous oak trees interspersed with sycamores and cottonwoods. The understory is herbaceous, composed of various grasses and riparian scrub. Oaks range in height from 5 feet to 40 feet. Because this area is adjacent to the river, sediment builds

In 1986 and 1987, maintenance operations for the Sacramento River Flood Control Project were carried out by the Department of Water Resources to remove this accumulated sediment both upstream and downstream of the weir. Mature trees were saved by excavating around them, and the area was seeded with grasses. Downstream of the weir, riparian forest is found adjacent to the Old River channel and in several other clumps as shown in Figure 2. Riparian scrub composed of blackberry, poison oak and wild rose is also found in this upper portion of the Yolo Bypass. Interspersed with this is valley grassland composed of wild oat, foxtail, needlegrass and yellow star thistle. There are also areas of freshwater emergent marsh (sedges, bullrush, pondweed, and cattails) in this area. This mix of vegetation is found from the Fremont Weir south for approximately one mile. South of this area the central part of the bypass is farmed and riparian vegetation is confined to canals and toe drains.

Riparian forest and scrub is found adjacent to the Tule Canal, Knights Landing Ridge Cut, and various toe drains adjacent to the waterside of the levees. The Tule Canal supports a linear band of riparian vegetation, mostly cottonwoods, willows, and tules on its bank. Knights Landing Ridge Cut empties into the bypass on the west side. Emergent marsh, dense willow thickets, and cottonwoods are supported in this area. Figure 2 shows the location of these resources.

7.2 Environmental Impacts - Yolo Bypass

A. **No Action**. Under this alternative, vegetative patterns are not expected to change significantly. The majority of the riparian vegetation is located near the toe drains or canals that are necessary for irrigation. The remaining land is farmed. Maintenance activities carried out in 1986 and 1987 removed sediment from in front of and behind the Fremont Weir resulting in the removal of grassland and riparian scrub vegetation. These areas were seeded and revegetated the following year.

B. **Modify Fremont Weir and Yolo Bypass**. Under the setback levee option, impacts would stem from the possible destruction of vegetation due to construction activities required to set back the east levee. Direct impacts to riparian vegetation could be minimized by excavating from the landside of the levee. Riparian vegetation in the Yolo Bypass is located in toe drains and canals waterside of the levees, with agricultural lands located landside of the levees. By setting back the east levee in a landward direction and excavating from the landside of the levee, impacts to riparian vegetation would be limited to that found directly waterside of the east levee. (See Figure 2.)

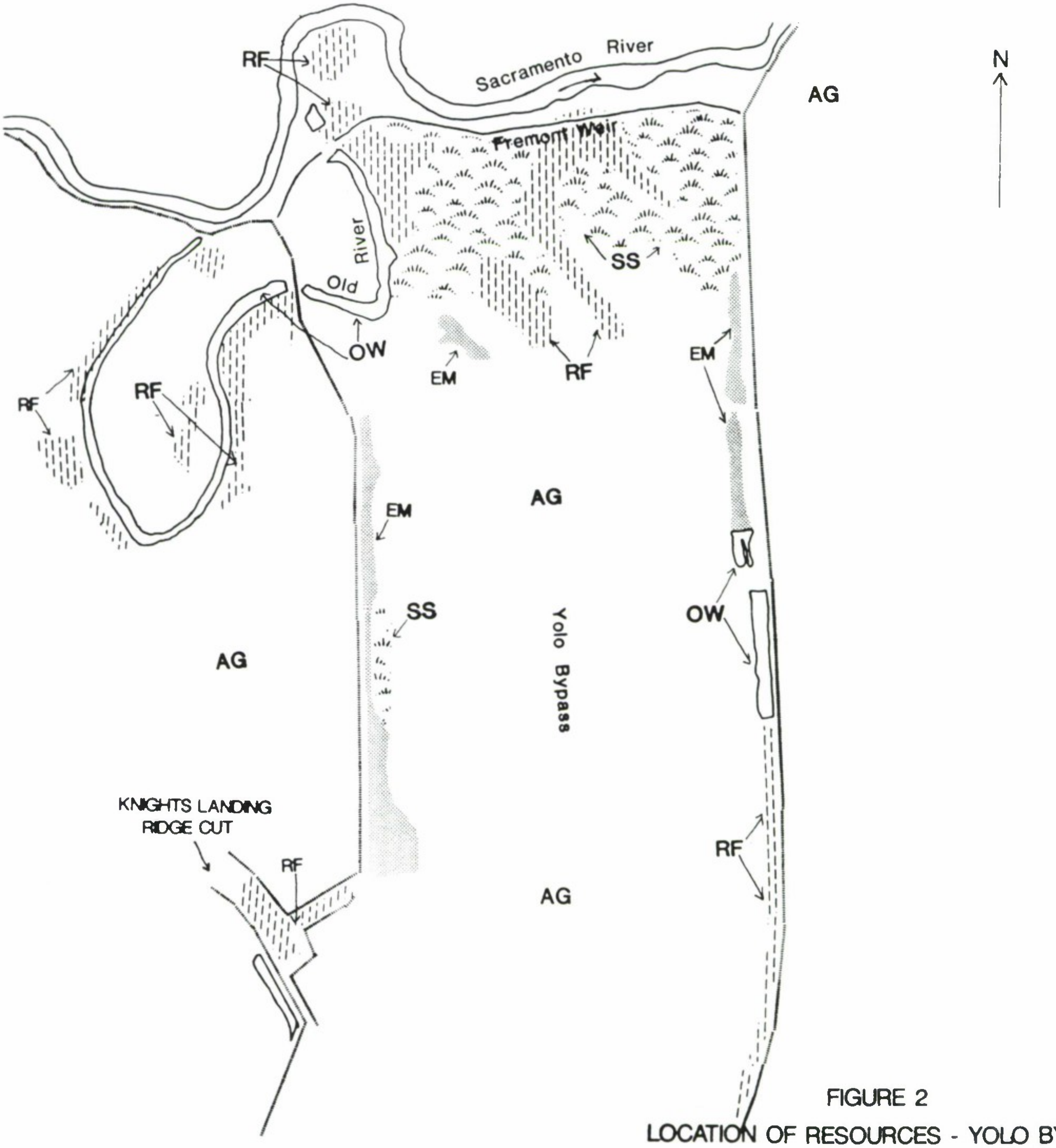


FIGURE 2
LOCATION OF RESOURCES - YOLO BYPASS
LEGEND
OW - OPEN WATER SS - RIPARIAN SCRUB
AG - AGRICULTURAL RF - RIPARIAN FOREST
EM - EMERGENT MARSH

Lowering the crest of Fremont Weir would increase the duration of flows in the bypass. Vegetation in the toe drains and canals are adapted to agricultural irrigation practices and are generally exposed to water year-round. Although species such as oaks located in the northern section of the Yolo Bypass are sensitive to prolonged inundation, the increase in duration will be minor (1 to 4 days per flood event at most) and will probably not impact these species. In addition to lowering the weir crest it may also be necessary to remove sediment from in front of and behind the weir. The impact of sediment removal would have a significant adverse impact to vegetative resources within the upper 1 mile of the Yolo Bypass. Approximately 190 acres of riparian forest (including valley oak woodland), 250 acres of riparian shrub/valley grassland, and 84 acres of freshwater emergent marsh could be impacted. Selective clearing of this area would lessen impacts by avoiding areas of riparian forest and the canals waterside of the bypass levees. This would limit impacts to riparian scrub and valley grassland.

C. <u>Modify Sacramento Weir and Bypass</u>. Modification of the Sacramento Weir could allow water to enter the Yolo Bypass earlier. This would not be a significant impact to riparian vegetation located within the Yolo Bypass.

D. <u>Divert Floodwaters into the Sacramento River Deep Water Ship Channel</u>. No impact to riparian vegetation within the Yolo Bypass area.

E. <u>Modify Levees Around West Sacramento</u>. Impacts to resources within the Yolo Bypass area are discussed in section 7.6(E).

F. <u>Remove Flow Constrictions from Yolo Bypass</u>. Impacts to resources within the Yolo Bypass are discussed in section 7.6(F).

G. <u>Combination</u>. Under this alternative any of the impacts described above would be possible.

7.3 <u>Affected Environment - Sacramento Bypass</u>. In this reach of the study area, the Sacramento River forms the eastern boundary. Vegetation along the river in the immediate vicinity of the Sacramento Weir consists of riparian scrub and grasses. Downstream of the weir, areas of mixed riparian forest line the Sacramento river. Within the bypass, toe drains located waterside of the levees contain riparian forest and riparian scrub. There are also areas of open water that contain some emergent marsh vegetation. Waterside of the north levee are toe drains containing dense, old growth cottonwood forest. The bypass is also designated as the Sacramento Bypass Wildlife Area and is managed for wildlife habitat within constraints of the area's primary purpose, which is flood control. Vegetation in the center of the bypass is sparse. Riparian vegetation is also found waterward of the south bypass levee. (See Figure 3.)

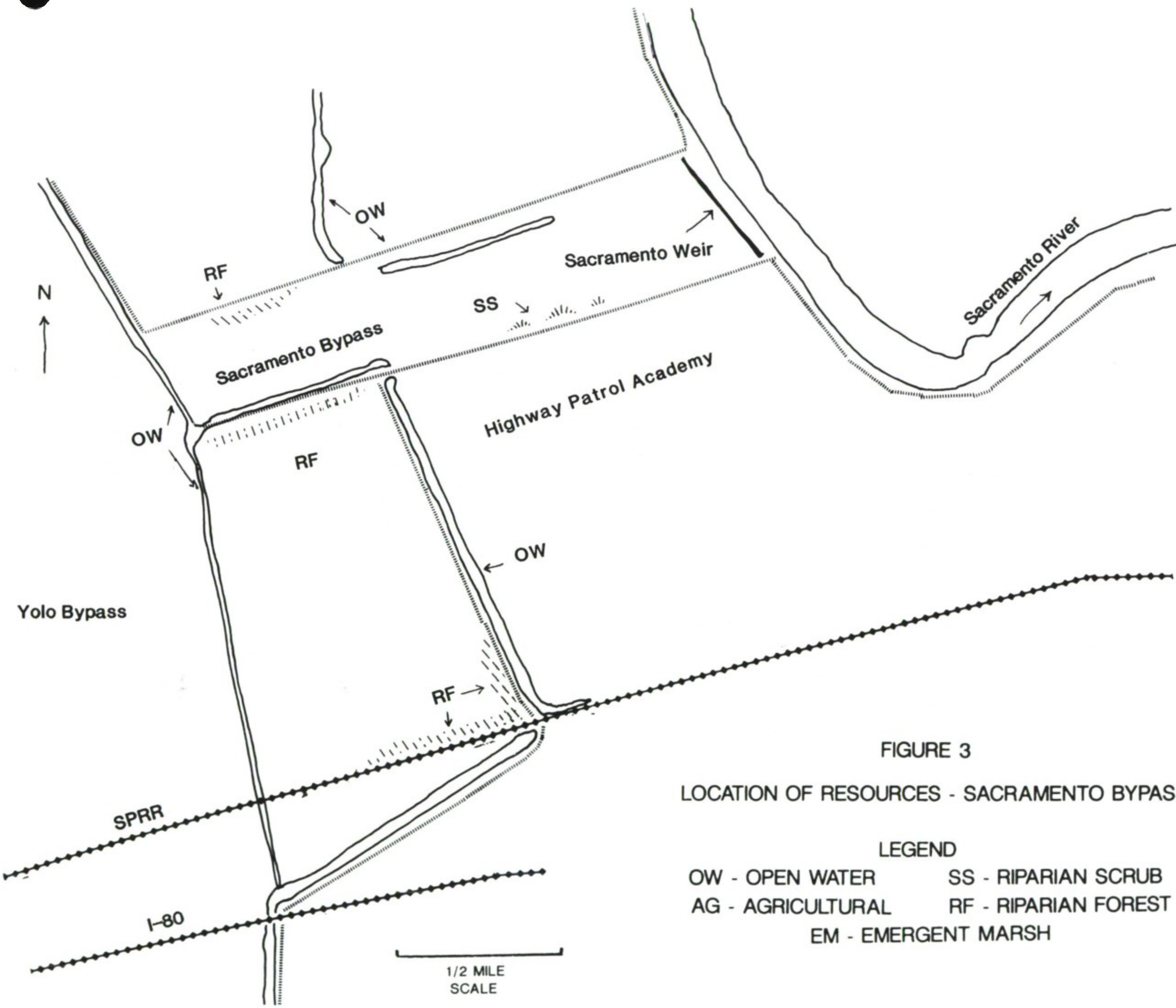


FIGURE 3

LOCATION OF RESOURCES - SACRAMENTO BYPASS

LEGEND

OW - OPEN WATER　　SS - RIPARIAN SCRUB
AG - AGRICULTURAL　　RF - RIPARIAN FOREST
EM - EMERGENT MARSH

7.4 Environmental Impacts - Sacramento Bypass.

A. No Action. Under this alternative, existing riparian vegetation is expected to remain intact. The riparian areas within the bypass are maintained as part of the Sacramento Bypass Wildlife Area. At present the Sacramento Weir and Bypass can convey the design flow within the design water surface elevation so there is no need to clear and/or remove sediment in the near future. The central area of the bypass does not contain riparian vegetation. Maintenance activities have selectively removed vegetation in the central area of the bypass.

B. Modify Fremont Weir and Yolo Bypass. No impact to riparian vegetation in the Sacramento Bypass.

C. Modify Sacramento Weir and Bypass. Under the setback levee option, impacts would stem from construction activities required to set back the north levee a distance of 500 or 1,500 feet. Any impact to the stand of old growth cottonwood located on the waterside of the north levee would be significant. The weir would be extended to tie into the setback levee. This extension would impact a small area of riparian scrub. The levee would be set back in a landward direction on to land used for agriculture.

Removing the gates from the Sacramento Weir would reduce control of flows within the Sacramento Bypass. This could impact areas of riparian scrub located in front of the weir by increasing the erosive forces that contribute to vegetative loss.

Under the third option, which is to lower the weir crest one foot, it may be necessary to remove sediment from within the bypass. Without selective clearing (avoiding the toe drains waterside of the levees) this could adversely impact riparian forest and riparian scrub. Lowering the weir crest would increase the volume of water diverted down the bypass and may increase the erosive forces contributing to vegetative loss.

D. Divert Floodwaters into the Sacramento River Deep Water Ship Channel. No impact to riparian vegetation in the Sacramento Bypass.

E. Modify Levees Around West Sacramento. Impacts to the levees of the Sacramento Bypass are discussed in section 7.6 (E).

F. Remove Flow Constrictions from Yolo Bypass. No impact to riparian vegetation in the Sacramento Bypass.

G. Combination. This alternative could result in any of the impacts discussed above.

7.5 Affected Environment - West Sacramento. Within this reach of the study area, riparian vegetation is confined to linear strips along the Sacramento River, toe drains waterward of the Yolo Bypass levees, and south of the cross levee as shown in Figure 4. Putah Creek empties into the Yolo Bypass on the western side. At its terminus there are areas of riparian scrub and forest. Land in the West Sacramento area is used for agricultural, industrial, and residential purposes, and riparian vegetation is limited to drainage ditches. The levee adjacent to the east side of the Ship Channel is sparsely vegetated with grasses and forbs.

7.6 Environmental Impact - West Sacramento.

A. **No Action**. Under this alternative it is possible that vegetative resources adjacent to the Sacramento River may decline as marinas and other riverfront areas are developed. As the West Sacramento area continues to urbanize, remnant riparian vegetation found in drainage ditches would decline.

B. **Modify Fremont Weir and Yolo Bypass**. No impact to riparian vegetation in the West Sacramento area.

C. **Modify Sacramento Weir and Bypass**. No impact to riparian vegetation in the West Sacramento area.

D. **Divert Floodwaters into the Sacramento River Deep Water Ship Channel**. Construction of pumps or overflow weirs to allow a greater flow in the Ship Channel during floodflows would mainly impact areas of riparian shrub. Scattered cottonwoods are found along the crown of the Ship Channel levee, and there are areas of emergent wetland within the Ship Channel. While raising water levels in the Ship Channel would probably not affect the scattered cottonwoods, the emergent wetland within the Ship Channel could be affected by submerging it for an extended period.

E. **Modify Levees Around West Sacramento**. Modification of levees involves raising and widening the levees to increase levels of flood protection. Modification of the west Sacramento River levee would impact areas of riparian scrub and riparian forest in the vicinity of Raley's Landing near the I Street Bridge.

Other levees that would be modified under this alternative include those of the Sacramento Bypass and the Yolo Bypass south of the Sacramento Bypass. Modification of all levees is expected to be toward the landside.

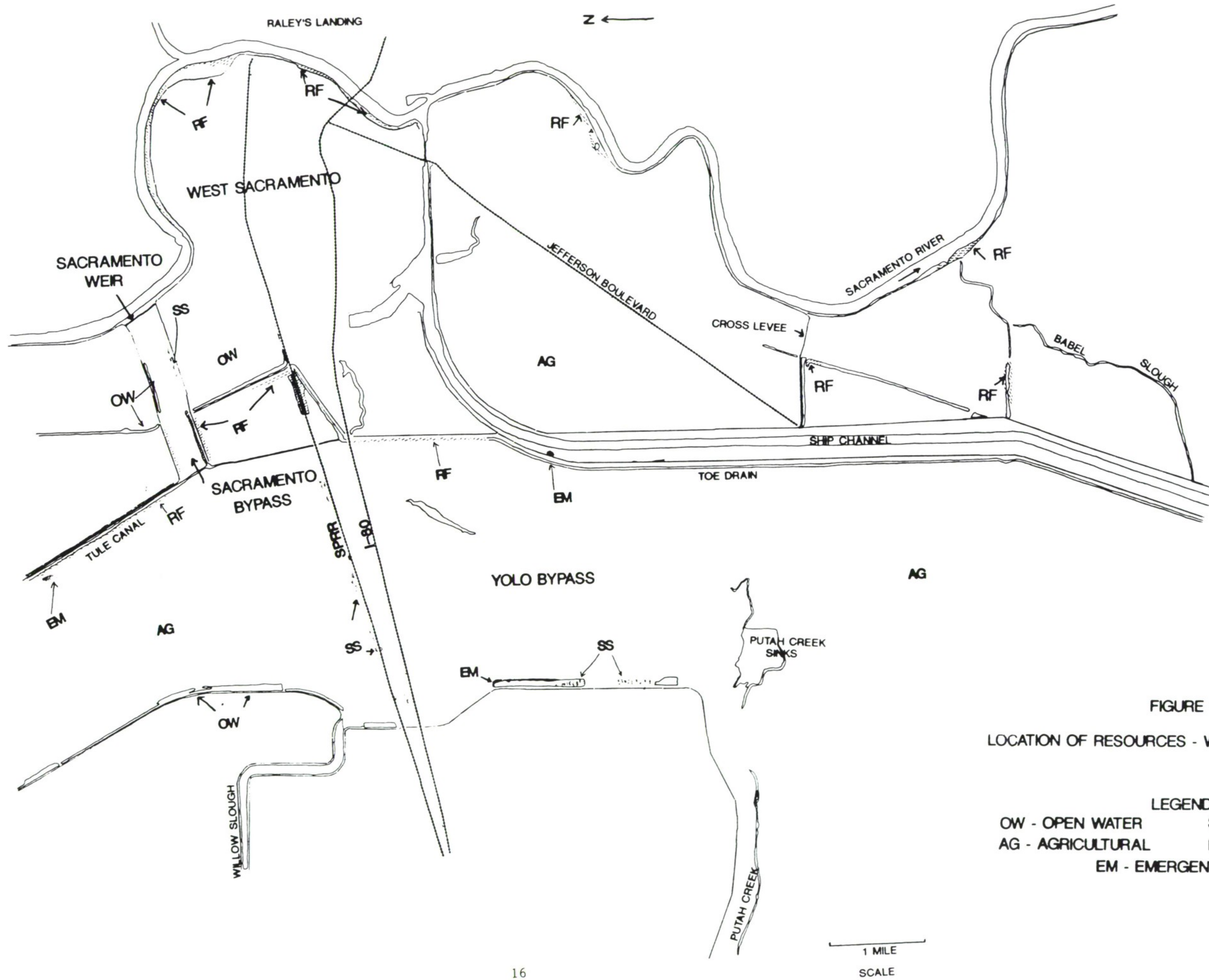


FIGURE 4

LOCATION OF RESOURCES - WEST SACRAMENTO

LEGEND

OW - OPEN WATER
AG - AGRICULTURAL
SS - RIPARIAN SCRUB
RF - RIPARIAN FOREST
EM - EMERGENT MARSH

Along the Sacramento Bypass landside modification would result in less impacts than waterside modification. Landside of the north levee land is used for agriculture and landside of the south levee is the California Highway Patrol Academy. Both areas contain little riparian vegetation. Waterward of these levees there are areas of riparian vegetation that could be impacted if levees were modified in this direction.

Along the Yolo Bypass impacts would be similar. Landward of the levee grasses are predominant, while waterward of the levee there is a toe drain containing riparian and emergent marsh vegetation. (See Figure 4.) Construction would be confined to the landside.

F. __Remove Flow Constrictions from Yolo Bypass__. This alternative impact areas of riparian scrub and slope stabilization plants located along both road and railroad beds (Interstate 80 and the Southern Pacific Railroad). The road beds would be replaced with bridge structures.

G. **Combination**. Any of the impacts described above would be possible under this alternative.

8.0 Fisheries

The Sacramento River forms the eastern boundary of the study area and provides important habitat for an abundant and diverse variety of both anadromous and resident species. The Sacramento River supports striped bass, steelhead trout, American shad and four races of chinook salmon. The Sacramento River provides both spawning and rearing habitat for these species. Within the study area, striped bass can be found from April to June during spawning runs. American shad are also in the study area from April to June during spawning migrations. Juvenile shad are present from July through November during outmigration. Steelhead trout use the river as a migratory corridor to and from spawning grounds on tributary streams. Chinook salmon spawn upstream of the study area but juvenile and adult chinook salmon can be found in the project area almost year-round. These species provide extensive recreational opportunities for fishermen in this area.

Resident species in the river include catfish, black bass, largemouth bass, black crappie, warmouth, Sacramento squawfish and Sacramento sucker. These resident species spend their entire life cycle in the Sacramento River. Most prefer shoreline areas along vegetated levees. Shaded riverine aquatic habitat is formed by a dense canopy of woody riparian vegetation that overhangs the water. This habitat provides complete shade during a portion of the day and provides essential spawning cover for these species, sunfish and catfish in particular. This cover type also benefits coldwater species such as juvenile salmon,

striped bass and steelhead trout by providing cooler water temperatures, protection from some avian predators, increased niches for hiding, and improved feeding.

8.1 Affected Environment - Yolo Bypass. Floodflows of the Sacramento River are diverted into the Yolo Bypass at the Fremont and Sacramento Weirs. Floodflows empty into the Sacramento-San Joaquin Delta at the southern end of the Yolo Bypass. At the same time, fish species that inhabit the river are diverted into the bypass and conveyed toward the Delta. During floodflows fish reside along the edge of the Yolo Bypass where vegetative cover is available. When flows recede, depressions within the bypass form temporary pools, and fishes not flushed out of the bypass are stranded. Because of its intermittent nature, the bypass area does not support permanent fish populations. The Tule Canal and toe drains located on the waterside of the Yolo Bypasses provide year round habitat for warm water species such as carp and catfish. The toe drains also provide year-round recreational opportunities for fishermen.

8.2 Environmental Impacts - Yolo Bypass.

A. **No Action**. Aquatic resources in the Sacramento River could decline. A potential threat to aquatic resources are future demands for the diversion of water for agricultural, municipal, and industrial purposes. An ongoing problem within the bypass is the stranding of adult and juvenile fish in temporary pools as floodflows recede. Toe drains are maintained with water for agricultural purposes year round, and the associated warm water fishery is not expected to decline.

B. **Modify Fremont Weir and Yolo Bypass**. Under the setback levee option, impacts to fisheries could result from construction activities leaving depressions within the bypass. Creation of additional isolated pools in the bypass from construction activities required to setback the levee could contribute to the ongoing stranding problem of adult and juvenile fish. With the increase of water diverted through the Yolo Bypass, additional fish may be diverted also. Although the Yolo Bypass does not provide optimum fish habitat, it is not likely that fish will reside here for long as floodflows flush them through to the Delta.

Under the option to lower the elevation of the weir crest and remove sediment from within the bypass aquatic impacts could occur through uneven grading of the bypass. Uneven grading would leave temporary pools in which fish are stranded as floodwaters recede. This option would also cause a slight increase in the length of time that flows stay in the bypass (1 to 4 days per flood event at most). This increase is not likely to impact fisheries.

C. Modify Sacramento Weir and Bypass. Under this alternative, flows could enter the Yolo Bypass earlier. With this earlier diversion additional fishes could also be diverted and stranded within the bypass.

D. Divert Floodwaters into the Sacramento River Deep Water Ship Channel. No impact to fishery resources in the Yolo Bypass.

E. Modify Levees Around West Sacramento. No impact to fishery resources in the Yolo Bypass.

F. Remove Flow Constrictions from Yolo Bypass. This alternative would not have a significant affect on fisheries.

G. Combination. Under this alternative, any of the impacts described above would be possible.

8.3 Affected Environment - Sacramento Bypass. Fisheries resources in this area are similar to those found in the Yolo Bypass. Toe drains on the waterside of the levees provide year-round habitat for warm water species. The bypass provides temporary habitat for species from the Sacramento River during floodflows. There is also an ongoing problem of fish stranding as is found in the Yolo Bypass.

8.4 Environmental Impacts - Sacramento Weir and Bypass.

A. No Action. No decrease of fisheries in the toe drains is expected, but increased water diversions upstream of the study area may cause a decline in the aquatic resources of the Sacramento River.

B. Modify Fremont Weir and Yolo Bypass. No impact to resources in the Sacramento Bypass.

C. Modify Sacramento Weir and Bypass. Under the setback levee option, impacts would be similar to those in the Yolo Bypass. Construction activities associated with setting back the north levee of the Sacramento Bypass could contribute to the problem of stranding adult and juvenile fish by creating additional temporary pools.

Removal of the gates on the Sacramento Weir would not change the duration of flows within the bypass, but would change the flow regime during the period of time that floodflows are in the bypass. As floodflows are diverted through the bypass so are fish from the Sacramento River. It is likely that floodflows would flush these fish out to the Delta, but those not flushed through could be exposed to increased predation (through lack of cover) and stranding.

Lowering the weir crest would increase the volume and duration of floodwater diverted through the bypass. This could result in an increased number of fish being diverted through the

bypass and possibly stranded. In addition, sediment removal which may be necessary with this option could create additional temporary pools, and create additional stranding problems.

D. Divert Floodwaters into the Sacramento River Deep Water Ship Channel. No impact to resources in the Sacramento Bypass.

E. Modify Levees Around West Sacramento. No impact to resources in the Sacramento Bypass.

F. Remove Flow Constrictions from Yolo Bypass. No impact to resources in the Sacramento Bypass.

G. Combination. Under this alternative any of the impacts described above would be possible.

8.5 Affected Environment - West Sacramento. The Ship Channel is frequented by high value anadromous sport species such as the king salmon, striped bass, and steelhead. Resident species include the channel catfish, brown bullhead, and a variety of sunfish. Fisheries found in the Sacramento River are described in section 8.0.

8.6 Environmental Impacts - West Sacramento.

A. No Action. Under this alternative any change in fish populations of the Sacramento River would be reflected in the Ship Channel. A decline in fish populations due to increased water diversions upstream of the study area would be reflected.

B. Modify Fremont Weir and Yolo Bypass. No impact to fishery resources in West Sacramento.

C. Modify Sacramento Weir and Bypass. No impact in to fishery resources in West Sacramento.

D. Divert Floodwaters into the Sacramento River Deep Water Ship Channel. Under this alternative floodwaters would be diverted from either the Sacramento River or the Yolo Bypass, into the Ship Channel. Water would be diverted by pumping it through a siphon, or constructing overflow weirs. Fisheries impacts associated with these methods would be minimal. Diverting the water through a siphon would require a pump to initiate the flow. The gravity flow of the siphon would divert water without continuous use of pumps. Fishery impacts would be limited to the initial pumping action to begin the flow. Although the Ship Channel does not provide optimum fish habitat, fish would be flushed through the Ship Channel into the Delta by the floodflows and would probably not reside in the Ship Channel for an extended period of time. The construction and use of overflow weirs to divert floodwaters is not likely to impact fisheries.

E. Modify Levees Around West Sacramento. Modification of the west Sacramento River levee near Raley's Landing would probably have minimal impact on fisheries. Construction would be performed landside, away from the river. Modification of the levees of the Sacramento and Yolo Bypasses would also be toward the landside, and would have little impact to fisheries located in toe drains waterside of the levees.

F. Remove Flow Constrictions from Yolo Bypass. This alternative would not impact fisheries.

G. Combination. Under this alternative, any of the impacts described above would be possible.

9.0 **Wildlife** resources are generally associated with the type of vegetative habitat available for food, cover and nesting. Vegetation types are described in section 7.0; wildlife species associated with these habitats are described below.

9.1 Affected Environment - Yolo Bypass. Riparian forest, valley oak woodland and freshwater marsh areas found along the toe drains of the bypasses and the Sacramento River are highly productive wildlife areas. They provide food, cover, and nesting habitat for both resident and migratory species. Species found in these areas include the house finch, scrub jay, acorn woodpecker, Virginia opossum, gray fox, raccoon, western gray squirrel, and ground squirrel. The large cottonwood and oak trees of the riparian forest and valley oak woodland provide nesting habitat for raptor species such as owls, red-tailed hawks, and Swainson's hawks. Swainson's hawks have been sighted throughout the study area. In addition vertical banks created by river erosion along the Sacramento River provide nesting habitat for the bank swallow, a species of special concern. There is a documented bank swallow colony within the study area located on the Sacramento River near the east side of Fremont Weir. During the winter months the Yolo Bypass is used extensively by migratory waterfowl and is also an important wintering area for raptors. Emergent marsh vegetation found in toe drains waterward of the bypass levees provide forage and nesting areas for egrets and bitterns. Also found in these areas are the marsh wren, red-wing black bird and muskrat.

The open grassland and riparian scrub areas are used by a variety of species that feed on seeds and vegetation. Example species include the California ground squirrel, California vole, California quail and American goldfinch. Vertebrate predators associated with this community include the gopher snake, red-tailed hawk and striped skunk.

Agricultural fields support wildlife types similar to those found in the grassland areas. Waterfowl species frequently use agricultural fields, especially during migration. However,

agricultural fields are more frequently disturbed and lack sufficient cover to support species as diverse as found in grassland areas.

Species observed during site visits to the study area include the great blue heron, common egret, killdeer, red-tailed hawk, muskrat, oriole and ground squirrel.

9.2 Environmental Impact - Yolo Bypass

A. **No Action**. Wildlife resources are not expected to change significantly under this alternative. The riparian vegetation in this area is expected to remain and to support wildlife species as described above.

B. **Modify Fremont Weir and Yolo Bypass**. Under the setback levee option, impacts to wildlife would vary depending on the quantity of riparian vegetation and freshwater marsh areas lost due to construction activities required to set back the east levee of the Yolo Bypass. Loss of mature cottonwoods and oaks would result in a loss of habitat for species such as hawks, owls and raccoons. Loss of freshwater marsh would result in a loss of habitat for species such as the marsh wren and muskrat.

Lowering the weir crest would have the effect of extending the period of inundation. If this inundation period adversely affects oaks located in the bypass, this would impact those wildlife species associated with that habitat by eliminating necessary food and cover. This alternative would, however, extend the length of time that migratory and resident waterfowl could use the bypass for resting and feeding. Conversely, it would decrease availability of forage area and prey for species including carnivores and raptors. In addition, sediment removal could impact riparian scrub, grassland, and riparian forest. Selective clearing would limit impacts to areas of riparian scrub and grassland, and reduce impacts to wildlife species such as raptors, passerine birds and small mammals.

C. **Modify Sacramento Weir and Bypass**. No impact to wildlife resources in the Yolo Bypass.

D. **Divert Floodwaters into the Sacramento River Deep Water Ship Channel**. No impact to wildlife resources in the Yolo Bypass.

E. **Modify Levees Around West Sacramento**. No impact to wildlife resources in the Yolo Bypass.

F. **Remove Flow Constrictions from Yolo Bypass**. Impacts are discussed in section 9.6(F).

G. **Combination**. Any of the impacts described would be possible.

9.3 Affected Environment - Sacramento Bypass. Wildlife species found in this area are associated with riparian vegetation along the Sacramento River and toe drains waterward of the bypass levees. The large cottonwood trees waterward of the north levee provide nesting habitat for raptor species such as owls and hawks. Open water found waterward of both bypass levees provides foraging areas for waterfowl and shorebirds such as herons, egrets, bitterns and rails. Adjacent to the Sacramento River, there are areas of riparian scrub providing habitat for small mammals and birds including beaver, western flycatcher, yellow warbler and the song sparrow.

9.4 Environmental Impacts - Sacramento Bypass.

A. **No Action**. Because there is no expected decline of vegetation, wildlife species associated with this vegetation are not expected to decline.

B. **Modify Fremont Weir and Yolo Bypass**. No impact to wildlife resources in the Sacramento Bypass.

C. **Modify Sacramento Weir and Bypass**. One option under this alternative is to set back the north levee a distance of either 500 feet, or 1500 feet. Wildlife impacts would occur if the riparian vegetation located on the waterside of the north bypass levee is damaged or removed. Removal of this riparian vegetation and open water areas could displace wildlife that depend on it for food, cover, and nesting. Also under this option the Sacramento Weir would be extended to join the setback levee. This would have minimal impacts on wildlife resources of the Sacramento Bypass.

A second option under this alternative is to remove the gates from the weir. This would have the effect of changing the flow regime during the period of time that floodflows are in the bypass. This is not likely to affect wildlife resources of the bypass.

A third option is to lower the weir crest one foot and to remove sediment from in front of and behind the weir. This option would also have the effect of increasing the volume and duration of flows in the bypass. Removal of sediment which would be necessary for this alternative would necessitate removal of riparian scrub in front of the weir. This could displace wildlife such as the western flycatcher and yellow warbler.

D. Divert Floodwaters into the Sacramento River Deep Water Ship Channel. No impact to wildlife resources in the Sacramento Bypass.

E. **Modify Levees around West Sacramento**. No impact to wildlife resources in the Sacramento Bypass.

F. Remove Flow constrictions from Yolo Bypass. No impact to wildlife resources in the Sacramento Bypass.

G. Combination. Any of the impacts described above would be possible.

9.5 Affected Environment - West Sacramento. Wildlife resources in the West Sacramento area are associated with the riparian and emergent marsh vegetation found adjacent to the Sacramento River and along toe drains waterside of the bypass levees. Agricultural fields in this area provide foraging areas for species such as the red-tailed hawk, Brewer's blackbird, and black-tailed hare. These species often nest in nearby riparian areas and use agricultural fields and annual grassland for feeding.

9.6 Environmental Impacts - West Sacramento.

A. No Action. As the West Sacramento area urbanizes the agricultural fields that provide some forage areas for wildlife will be lost. Wildlife values associated with riparian areas waterside of bypass levees are expected to remain intact. Wildlife values associated with riparian vegetation adjacent to the Sacramento River will remain provided that this vegetation is not removed.

B. Modify Fremont Weir and Yolo Bypass. No impact to the wildlife resources of the West Sacramento area.

C. Modify Sacramento Weir and Bypass. No impact to the wildlife resources of the West Sacramento area.

D. Divert Floodwaters into the Sacramento River Deep Water Ship Channel. Wildlife species would be affected where vegetative cover is removed to install pumping facilities and to modify levees. This cover consists of grassland and riparian scrub. If this alternative is identified for further study, impacts would be further defined.

E. Modify Levees Around West Sacramento. Under this alternative, impacts to wildlife would occur from elimination of vegetation necessary for food, cover and nesting. Modification of all levees is expected to be towards the landside. Along both the Yolo and Sacramento Bypasses, modification toward the landside would limit impacts to the sparsely vegetated landside. The landside vegetation is of much lower value to wildlife than the riparian and emergent marsh vegetation found waterside of the levee. Impacts to wildlife from modification of the west Sacramento River levee would be from the removal of riparian forest and scrub.

F. <u>Remove Flow Constrictions from Yolo Bypass</u>. This alternative would require the removal of the riparian scrub located along both road beds. This vegetation is sparse and does not provide a significant amount of wildlife habitat.

G. <u>Combination</u>. Any of the impacts described above would be possible.

10.0 Rare, Threatened, and Endangered Species

The study area supports a variety of plant and animal life. Many unique species are specifically dependent on riparian areas within the study area. As alternatives are further defined in the Feasibility Phase, a detailed study will be conducted of the impacts to these species. The giant garter snake (*Thamnophis couchi gigas*), a state threatened species and federal candidate species, may occur in the study area. Swainson's hawk (*Buteo swainsoni*), also a state threatened and federal candidate species is known to occur in the study area. The Tricolored blackbird (*Agelaius tricolor*) which may occur in the project area, is a candidate for federal listing. Another bird species of concern that is not on either federal or state lists is the bank swallow (*Riparia riparia*). This species is protected under the Migratory Bird Treaty Act and is a species of special concern.

A plant species of concern that may be in the project area is the California hibiscus (*Hibiscus californicus*), a federal candidate species.

Fish species that have been recommended for the federal candidate list are the Sacramento perch (*Archoplites interruptus*) and Sacramento splittail (*Pogonichths macrolepidotus*).

The threatened valley elderberry longhorn beetle (*Democerus californicus dimorphus*) may also be found within the project area.

At the feasibility stage of this investigation, a list of endangered/threatened species will be requested from the Fish and Wildlife Service, and a list of state protected species will be obtained from the Department of Fish and Game. An assessment of impacts will then be prepared.

11.0 Cultural Resources

Although data from elsewhere in western North America suggests substantially longer occupation, data from the study area firmly establishes human presence for only the last 10,000 years. The intervening span of time to the historic period is evidenced by a sequence of various artifactual assemblages representing either different cultures or cultural adaptations to the region.

Anglo-Europeans first visited the study area in the late 1700s. However, it was not until the early part of the 19th century that western culture began to exert a strong and lasting influence on the character of the regions: initially as a result of exploration parties, later as a result of trading expeditions, and subsequently as a result of mining activity that led to substantial settlements.

A search of previously recorded cultural resources information on file at the various Information Centers of the California Archeological Inventory as of July, 1988 has been completed. Less than one percent of the study area has been surveyed. A summary of recorded cultural resource information for each reach is listed below.

1. Fremont Weir and Yolo Bypass. Existing information indicates less than 5 of the estimated 11,000 acres have been examined for cultural values. One site has been noted within this area, and three others are known to be in the immediate vicinity.

2. Sacramento Weir and Bypass. No prehistoric or historic resources are recorded within this area; however, only a fraction of this area has been surveyed (45 of the estimated 600 acres).

3. West Sacramento. As is the case with the other reaches, only a small part of this area has been surveyed. No sites have been recorded in the vicinity of the Ship Channel. There are six recorded archeological properties within or immediately adjacent to the levees surrounding West Sacramento. Only 6 of the 46 linear miles of levee have been intensively surveyed.

Consultation with the State Historic Preservation Officer has been initiated to determine what additional efforts should be completed in order to comply with Section 106 of the National Historic Preservation Act of 1966. The Office of Historic Preservation (OHP) recommended that a complete professional evaluation of resources that are likely to be affected as a result of the proposed project be completed in the feasibility phase. When this is completed the OHP will be able to assist the Corps in assessing impacts of the proposed project on historic properties.

12.0 Findings

Construction activities required to setback levees, remove sediment from bypasses, or modify levees would be the source of environmental impacts associated with flood control alternatives. Impacts to terrestrial resources includes the removal of riparian forest, riparian scrub, freshwater emergent marsh, valley grassland, valley oak woodland and open water habitats. Removal

or alteration of these habitats would adversely affect wildlife including threatened and endangered species dependent on these habitats for food, cover and nesting.

Aquatic impacts would come from increased depressions left within the bypass from construction activities. As water recedes fish may be stranded within these depressions. The increased diversion of water through the bypasses could result in additional fish being diverted through the bypasses. There is insufficient information at this time to determine the magnitude of this impact on fisheries. The magnitude of this impact could be evaluated in the feasibility phase of the investigation.

Resources discussed in section 6.0 are not likely to be significantly impacted. There would not be a significant impact to water quality since the proposed alternatives would be conducted away from the river. Short-term impacts relating to increased levels of dust and noise are expected, but there would be no significant long-term impacts.

Based on preliminary assessment of impacts expected to result from implementation of the flood control alternatives, it will be necessary to prepare an environmental impact statement (EIS) during the feasibility study.

Future studies will be needed to prepare an EIS and to determine suitable mitigation. In their planning aid letter of 12 October 1989, FWS recommended seven studies to be conducted in the feasibility phase (see Appendix A). Five reports would be prepared during the feasibility phase. These reports would incorporate the FWS recommended studies. These reports are:

1. A terrestrial and aquatic Habitat Evaluation Procedure analysis. This would include an assessment of existing terrestrial and aquatic resources in the toe drains, canals, borrow areas, and other areas affected by the project alternatives. This would also include an analysis of project impacts on fish and wildlife resources. This would incorporate FWS recommendations 1, 3, 4, 5 and 6.

2. A Coordination Act Report would be prepared by the U.S. Fish and Wildlife Service. This report would provide background information on existing resources, an analysis of with and without project conditions, and mitigation recommendations. This report would incorporate FWS recommendations 6 and 7.

3. A biological assessment on all endangered and threatened species in the study area. This would incorporate FWS recommendation 2.

4. A cultural resources survey of the project area will be necessary in order to complete site evaluations, mitigation plans, and Section 106 consultation requirements.

5. An incremental analysis of mitigation alternatives to determine the most suitable and economically justified mitigation to offset project impacts.

13.0 Mitigation

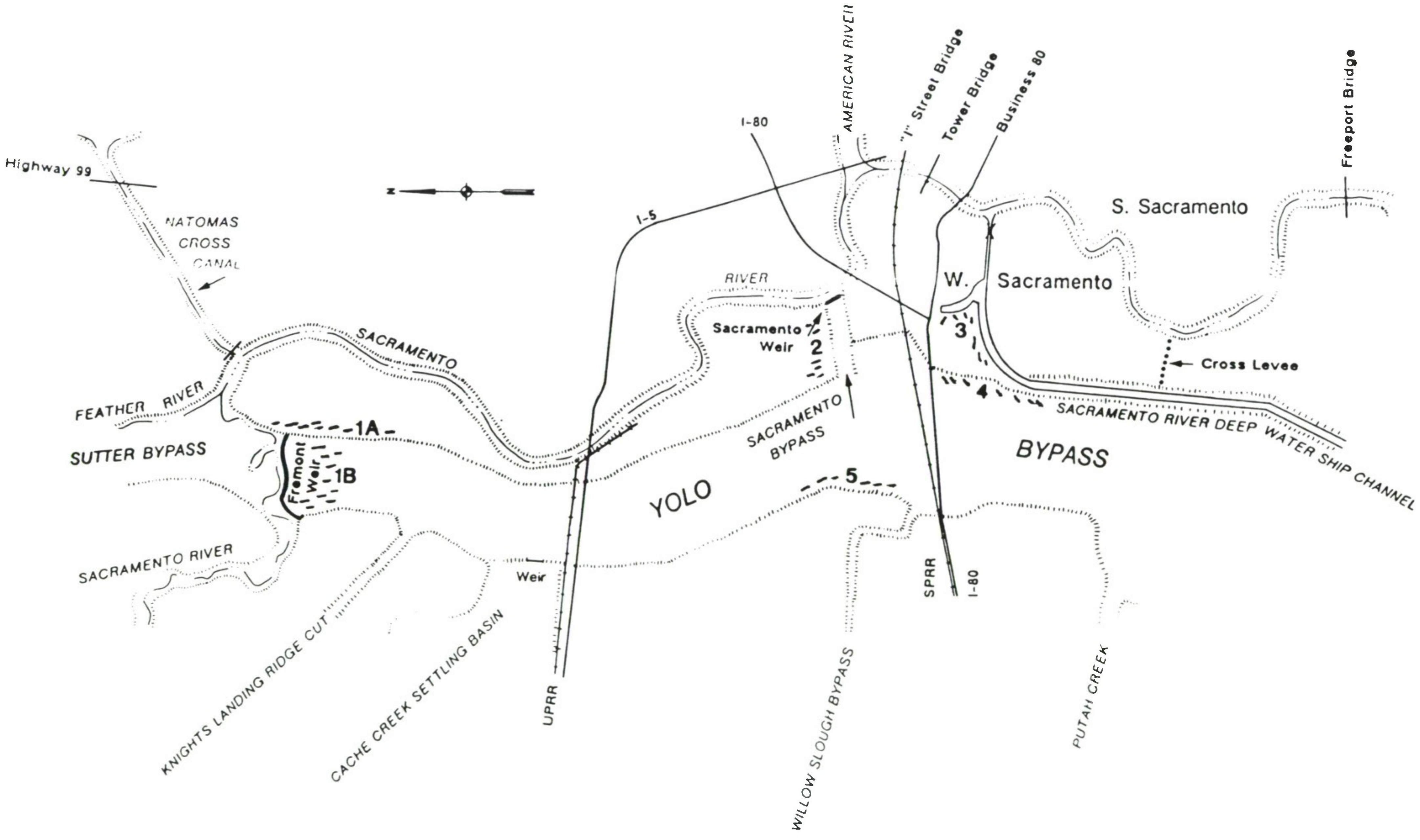
A conceptual outline of mitigation for projects impacts is presented below for each alternative. In the feasibility stage of the project, impacts and mitigation needs would be assessed with a habitat evaluation procedure analysis. Figure 5 shows the general location of mitigation areas.

A. Modification of Fremont Weir.

1. Setback east levee. Terrestrial impacts associated with this alternative stem from direct construction impacts. Mitigation for construction impacts associated with the option of setting back the east levee of the Yolo Bypass would consist of acquiring an easement (or local assurances as part of the project) over the Tule Canal to ensure it is not filled in or moved. A strip of land between the Tule Canal and the new setback levee could then be revegetated. An environmental easement could also be acquired for the revegetated land.

2. Lower crest of Fremont Weir and sediment removal. Lowering the crest of the Fremont Weir would cause a slight increase in the duration of flows within the Yolo Bypass - one to four days per flood at the most. Increased flow duration could cause damage to the oaks in the bypass but the magnitude of change is so small that the effects are probably minor. Mitigation for sediment removal within the upper portion of the Fremont Weir would include selective clearing. By selectively clearing the upper portion of the Fremont Weir, areas of riparian forest would be avoided, as would the toe drains waterward of the bypass levees. This would limit impacts to areas of riparian shrub/scrub. After sediment removal, areas of riparian shrub/scrub would be revegetated as was done by the Department of Water Resources in 1987.

Aquatic impacts under this alternative would stem from increased depressions left within the bypass from construction activities. As water recedes fish may be stranded within these depressions. Mitigation for this impact would consist of requiring construction areas to be graded with a slight slope towards the Tule Canal or toe drain. With proper grading provisions, impacts to fisheries should be minimal. The increase in volume of water passed into the Yolo Bypass could divert additional fish. It is possible that additional fish could be stranded in the bypass under this alternative. Studies during the feasibility phase could address this possibility.



1A REVEGETATION FOR SETBACK LEVEE OPTION

1B RESEEDING FOR SEDIMENT REMOVAL OPTION

2 REVEGETATION FOR SETBACK LEVEE OPTION

3 RESEEDING NEWLY CONSTRUCTED LEVEES AROUND PORT FACILITIES

4 REVEGETATION AREA FOR LEVEE MODIFICATION ALTERNATIVE

5 REVEGETATION AREA FOR REMOVAL OF EMBANKMENT MATERIAL

LEGEND

FEDERAL LEVEES

PRIVATE LEVEES

SACRAMENTO METROPOLITAN AREA
SACRAMENTO

FIGURE 5

LOCATION OF POTENTIAL MITIGATION AREAS

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
DECEMBER 1988

B. Modify Sacramento Bypass.

1. Setback north levee. Mitigation for the terrestrial impacts of setting back the north levee of the Sacramento Bypass would consist of revegetating a strip of land adjacent to the existing toe drain. An environmental easement would be acquired over the revegetated area.

2. Remove gates of the Sacramento Weir. This would not change the duration of floodflows within the bypass, but would change the flow regime during the time period that floodwaters are present in the bypass. Impacts to vegetation would probably be minor and not require mitigation.

3. Lower crest of Sacramento Weir and remove sediment. The increased volume of flows in the Sacramento Bypass would be minor. Sediment removal, if needed, would be removed near the weir and possibly through the central area of the bypass. Riparian vegetation in the toe drains would not be removed. Therefore, impacts to vegetation from this option are considered minor.

Aquatic impacts under this alternative would stem from increased depressions left within the bypass from construction activities. As water recedes fish may be stranded within these depressions. Mitigation for this impact would consist of requiring construction areas to be graded with a slight slope towards the Tule Canal or toe drain. With proper grading provisions, impacts to fisheries should be minimal. The increase in volume of water passed into the Sacramento Bypass could cause additional fish to be diverted also. It is possible that this could result in additional fish mortality. There is insufficient information at this time to determine whether or not this is a significant impact on fish. Studies during the feasibility phase could address this possibility.

C. Divert Floodwaters into the Ship Channel.

Terrestrial impacts of this alternative would be minor. Mitigation for construction of new levees around the port facilities would consist of vegetating the levees with native grasses. Specific areas in which diversion facilities would be built have not yet been identified.

Aquatic impacts under this alternative would also be minimal. Water would be diverted in one of two methods; by using a siphon with a pump, or by constructing overflow weirs. Fisheries impacts associated with these methods would be minimal.

D. Levee modification around West Sacramento.

Terrestrial impacts from levee modification could be mitigated by replanting along the toe drains waterward of the modified levees. Toe drains in this area do not have the riparian cover that is found toward the Fremont Weir. Replanting in this area could increase the linear extent of riparian cover in the area.

All construction activities for levee modification would be conducted on the landward side of the levee and would cause minimal aquatic impacts.

E. Remove embankment material from I-80 and SPRR.

Mitigation for terrestrial impacts of this alternative would consist of revegetation along the toe drain of the west levee of the Yolo Bypass.

All construction areas would be evenly graded resulting in minimal aquatic impacts.

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14.0 List of Preparers

Name Discipline/ Expertise	Experience	Role in Preparation
Dave Gundlach Water Resources Planning/Hydraulics and Hydrology	12 yrs Water Resources Related Activities, U.S. Army Corps of Engineers	Report review
Fred Kindel Wildlife Biologist/ Environmental Planner	23 yrs Environmental Planning Studies, U.S. Army Corps of Engineers 8 yrs State and Private Wildlife Management	Report review and editing
Karen Amerman Kuhn Civil Engineer/ Water Resources Plnr	1 yr Water Resources Planning, U.S. Army Corps of Engineers	Report review
Patricia Roberson Environmental Studies/ Environmental Planner	3 yrs Environmental Planning Studies, U.S. Army Corps of Engineers	Report preparation
Mike Welsh General Biologist/ Environmental Planner	12 yrs Environmental Planning Studies, U.S. Army Corps of Engineers	Report review and editing
Lynne Stevenson Technical Writer/ Editor	5 yrs Engineering & Planning Studies, U.S. Army Corps of Engineers 10 yrs Professional Librarian	Report review and editing

APPENDIX A

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Division of Ecological Services
2800 Cottage Way, Room E-1803
Sacramento, California 95825

October 12, 1988

Colonel Jack A. LeCuyer
District Engineer
Sacramento District, Corps of Engineers
650 Capitol Mall
Sacramento, California 95814

Subject: CE - Sacramento Metropolitan Area Investigation

Dear Colonel LeCuyer:

This planning aid letter includes fish and wildlife resource information and identifies potential impacts to these resources which could result from flood control measures presently being investigated for this project. The information provided is preliminary in nature and is provided as technical assistance for your reconnaissance level planning process. It does not constitute the detailed report of the Fish and Wildlife Service as required by Section 2 of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended, 16 U.S.C. 661 et seq.).

Our analysis is based on project information provided by the Corps of Engineers prior to June 15, 1988, a helicopter site survey on May 12, 1988, and ground site surveys on June 9, July 11 and August 9, 1988. The information provided herein has been coordinated with our Sacramento Endangered Species staff to ensure that they are consistent with their June 17, 1988 Section 7 letter to you listing Federally endangered and threatened species in the project area. The letter has also been coordinated with the California Department of Fish and Game; their concerns have been included.

DESCRIPTION OF THE AREA

The 160 square mile study area is located in Sacramento, Solano, Sutter and Yolo Counties, although most of the study area is in Sacramento and Yolo Counties. It includes portions of the Sacramento River Flood Control Project along the Sacramento River. The study area extends north of the City of Sacramento to Verona near the confluence of the Sacramento and Feather Rivers, south to the town of Freeport, west to the west levee of the Yolo Bypass, and east to the east levee of the Sacramento River, including some adjacent urban Sacramento areas not addressed in the American River Watershed Flood Control Investigation (Figure 1). Major features of the Sacramento River Flood Control Project included in the alternatives are the Fremont Weir and Yolo Bypass, Sacramento Weir and Sacramento Bypass, Sacramento River, and the levees associated with these features.

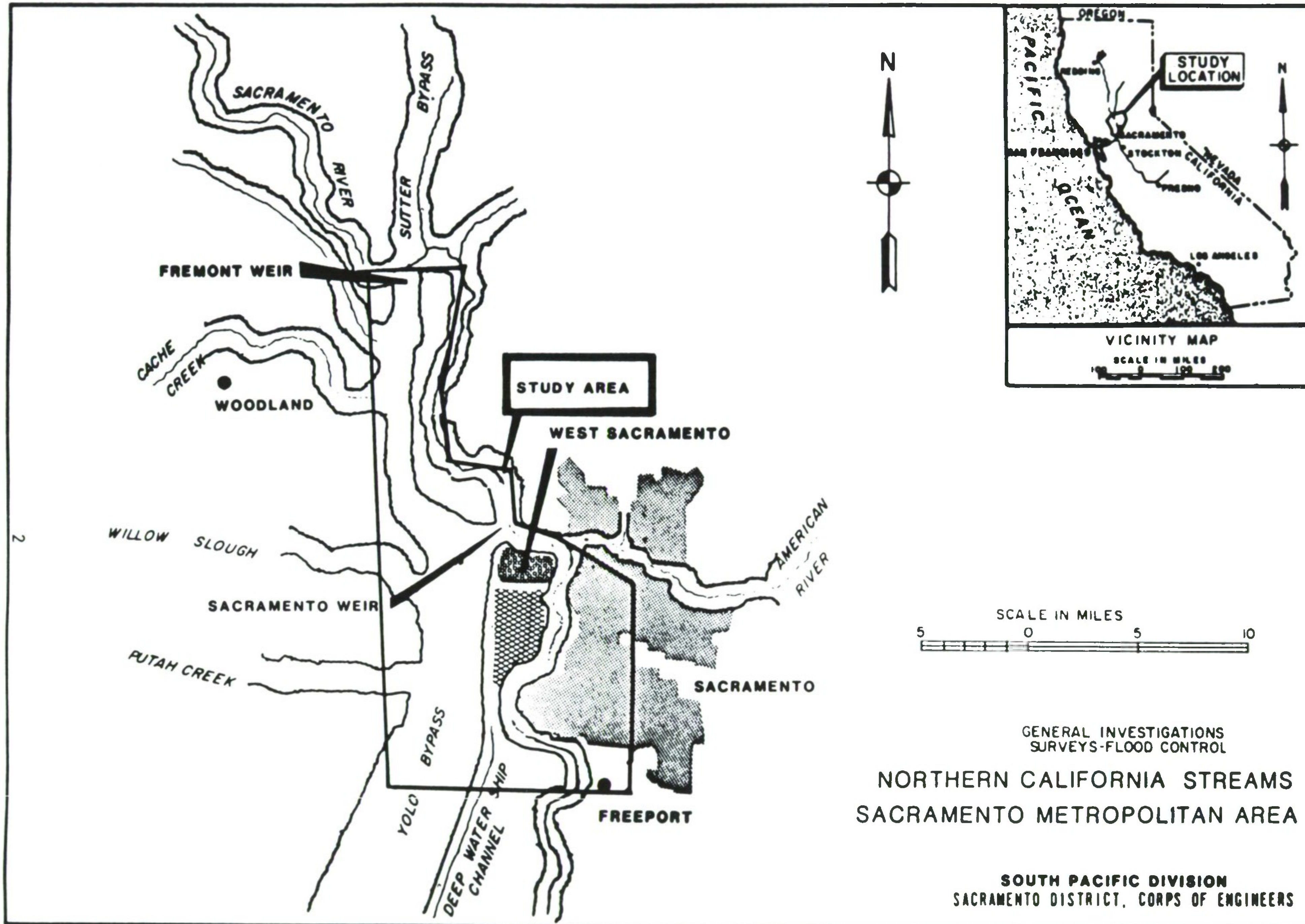


Figure 1. Study Area.

In addition, modifications at the Sacramento River Deep Water Ship Channel, Interstate Highway 80, and the Southern Pacific railroad bridge crossing over the Yolo Bypass are considered in the project alternatives. The Sacramento, Feather and American Rivers flow into the study area. Significant tributary streams which flow from the west into the Yolo Bypass include Cache Creek, Willow Slough, and Putah Creek. Other significant bodies of water within the study area include the Sacramento River Deep Water Ship Channel, Lake Washington, Winchester Lake, Putah Creek Sinks, Greens Lake, Todhunters Lake, numerous canals, and levee toe drains.

From Knights Landing (River mile 90), the Sacramento River flows past the Fremont Weir (River mile 84 to 82), Verona (River mile 79), the Sacramento Weir (River mile 63), the City of Sacramento (River mile 56 to 60), and the town of Clarksburg (River mile 42) before flowing into Suisun Bay near Collinsville. Both the Fremont and Sacramento Weirs divert flood waters from the Sacramento River into the Yolo Bypass. The Yolo Bypass conveys flood waters past the City of Sacramento downstream for about 50 miles before it empties into the Sacramento River just upstream of Rio Vista (River mile 14). The hydrology of the rivers, streams, lakes, canals, and sinks varies seasonally. During the winter and spring, water may be present in some or all of the systems during flood events, whereas in summer and fall the bypasses, sinks, and some drains typically are dry.

DESCRIPTION OF ALTERNATIVES

Major storm events in northern California, in February 1986, caused record flows in the American River Basin, which contributed to flooding problems throughout the Sacramento area. Floodwaters encroached upon the design freeboard of the levee in many locations, causing significant structural damage including levee erosion in the study area. Subsequently, concerns were raised about the current effectiveness of the Sacramento River Flood Control Project levee systems and level of flood protection they offered. To address these concerns, the U.S. Army Corps of Engineers, Sacramento District initiated a reconnaissance level study which is scheduled for completion in February 1989. The study will: (1) identify the level of flood protection provided by existing projects to the Sacramento area based on recent hydrologic and hydraulic evaluations, (2) identify the need for additional protection appropriate to the Sacramento urban areas, (3) evaluate the impact of future development within the Sacramento basin on future flood flows, and (4) evaluate the environmental impacts of alternative modifications to the existing flood control system.

Modifications of the existing flood control system in five general areas are being considered. The types of modifications are being refined as new information from Corps hydrology studies becomes available.

Alternative A: Increase flow over the Fremont Weir (Figure 2). Options within the alternative could include:

1. Removing sediment deposits from the front and behind the Fremont Weir. The California Department of Water Resources has already done some of this work within the last few years. The area of removal could extend from the Fremont Weir approximately eight miles down the Yolo Bypass. The clearing could be selective within the eight-mile area.

2. Modifying the crest elevation of the Fremont Weir.

3. Setting back the levees of the Yolo Bypass along this eight-mile reach.

4. Any combination of the above.

Alternative B: Modifying Sacramento Weir (Figure 2). This alternative could include:

1. Modifying the operation of the gates to change the flow regime, and modifying the water surface elevation at which flood waters would be diverted over the Sacramento Weir.

2. Modifying the Sacramento Bypass and Sacramento Weir to allow more flow into the Yolo Bypass. This could be accomplished by lowering the Sacramento Weir crest, widening the Sacramento Weir, or making a permanent weir like the Fremont Weir (remove gates).

3. Removing of sediment from the Sacramento Bypass both upstream and downstream of the Sacramento Weir.

4. Setting back the levees along the Sacramento Bypass.

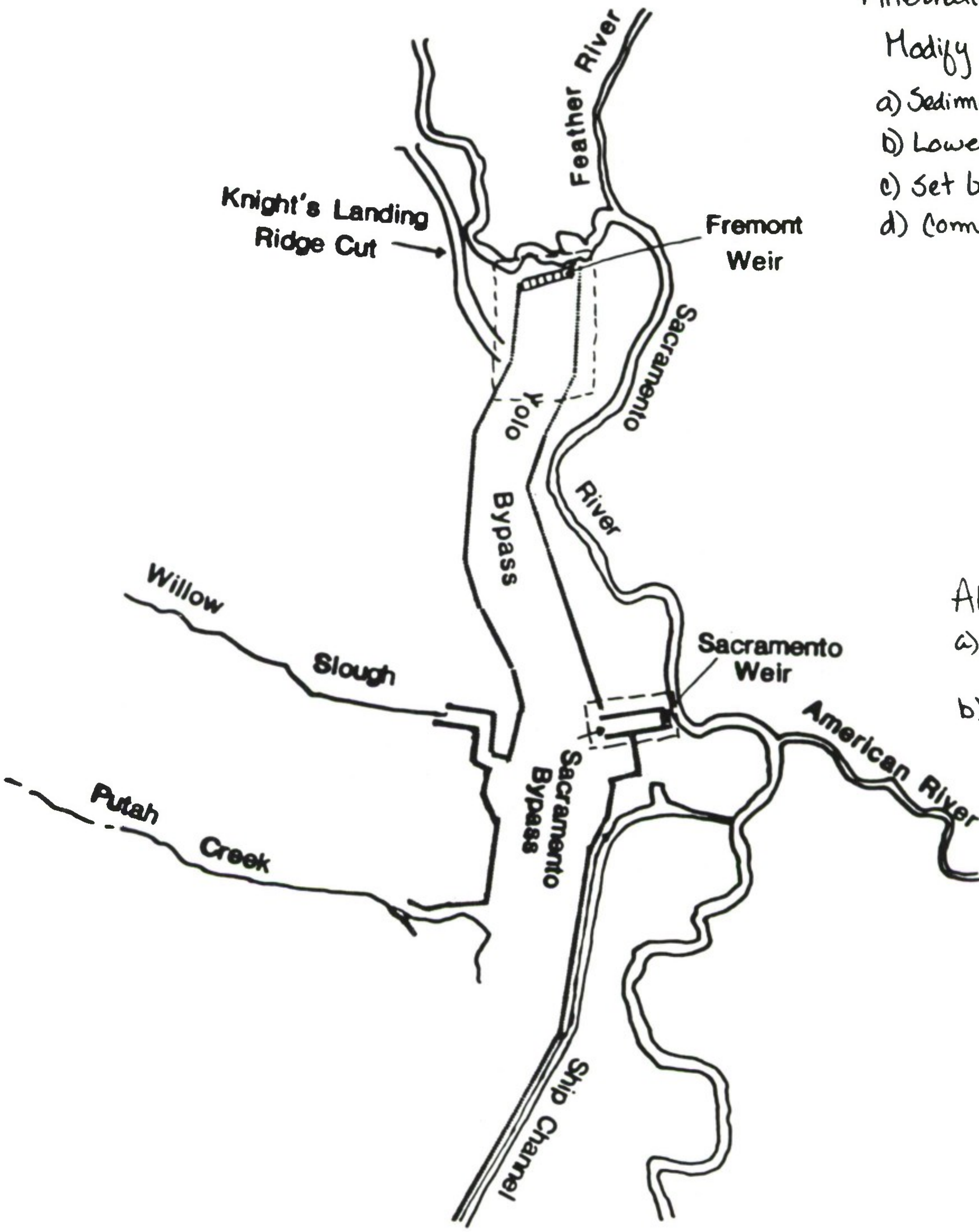
Alternative C: Use of Sacramento River Deep Water Ship Channel (Ship Channel) (Figure 3). This alternative could include:

1. Constructing additional levees around the port facilities and pumping of water into the Ship Channel from the Sacramento River and/or the Yolo Bypass.

2. Constructing diversion facilities which could divert water from either the Sacramento River or the Yolo Bypass into the Ship Channel. (The proposed diversion channels and pumps are shown in approximately the same location in Figure 4.)

Alternative D: Levee Modifications (Figure 4).

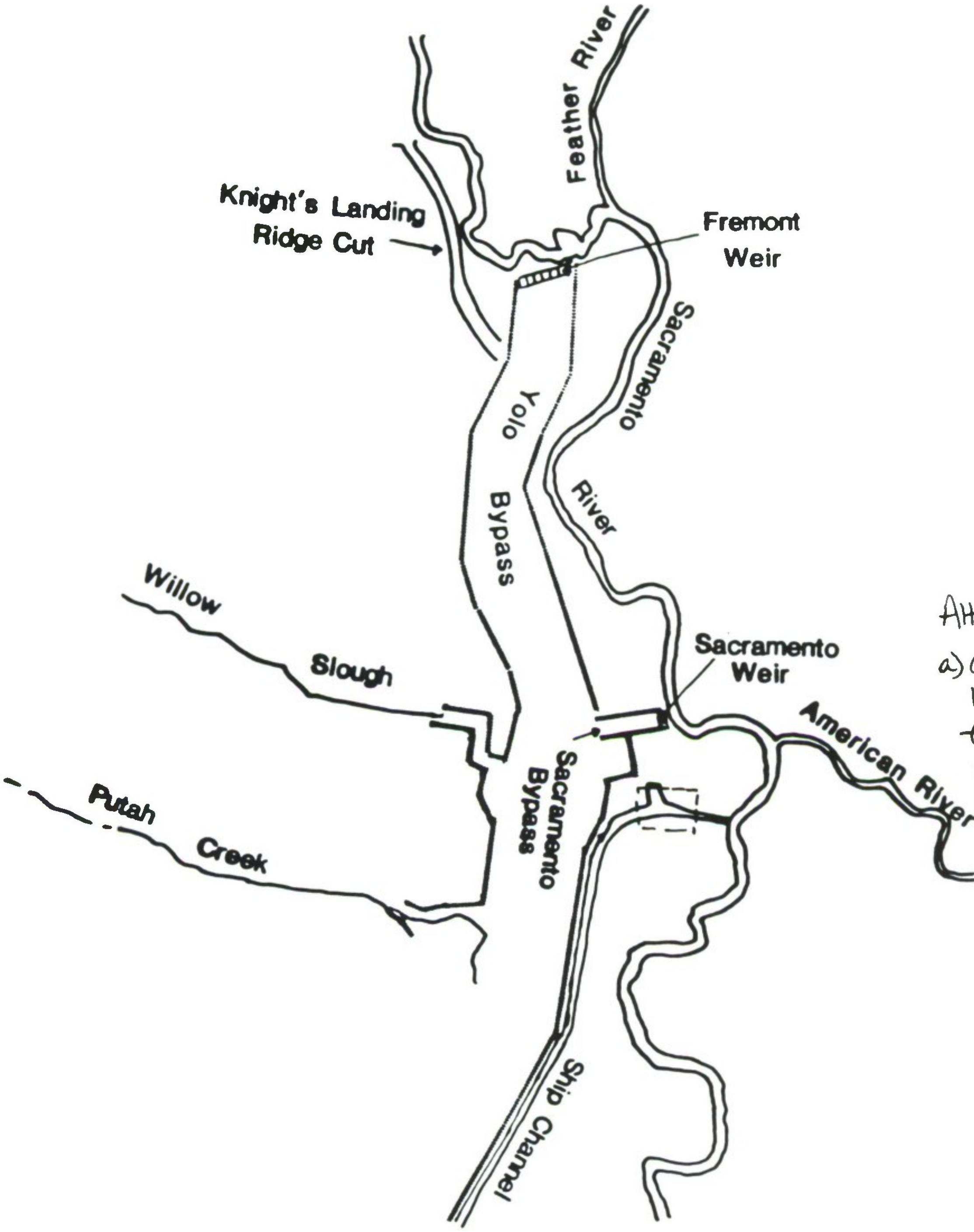
1. The Sacramento River levees have adequate freeboard (for 100 or 200 year protection levels) between Sacramento Bypass and Freeport except for a localized area of the west levee near the "I" Street bridge. This area would be raised from the landward side of the levee. The



Alternative A
Modify Fremont Weir
a) Sediment Removal
b) Lower weir crest
c) Set back levee
d) Combination

Alternative B
a) Remove gates and lower weir crest
b) Set back levee

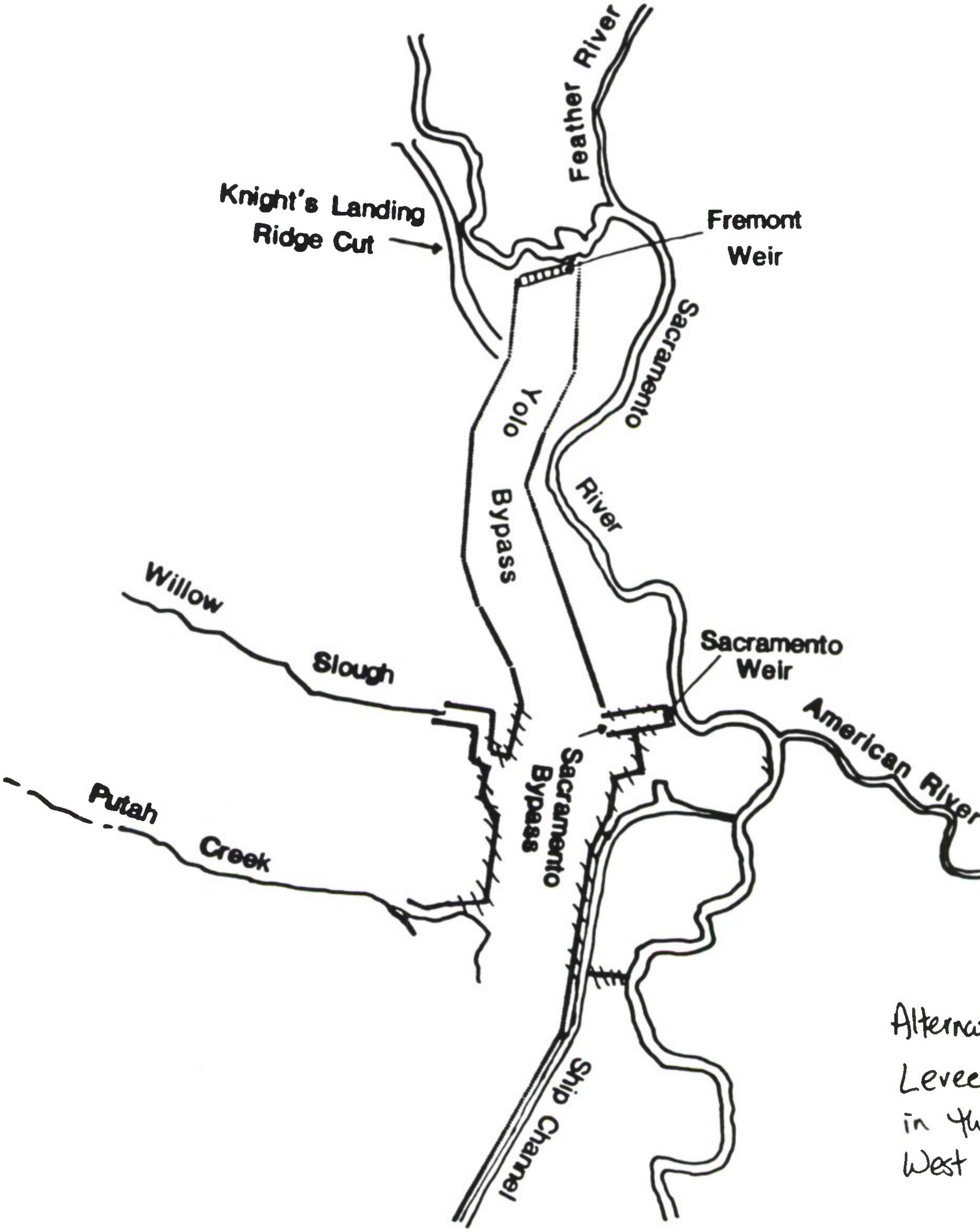
Figure 2



Alternative C

a) Construct additional levees around port facilities and pump water into Ship Channel from Yolo Bypass or Sacramento River.

Figure 3



Alternative D
Levee modification in the vicinity of West Sacramento

Figure 4

left (east) Yolo Bypass levee may be raised and widened toward the West Sacramento side (landward). The majority of easements are already available on the landward side of the levees around West Sacramento. The south cross levee between the Ship Channel and Sacramento River would be raised and widened. It may be necessary to raise the right (west) Yolo Bypass levee to compensate for raising the left Yolo Bypass levee in order to keep the system in balance. At this time, it is not known if it would be widened on the water or landward side.

Alternative E: Expand Yolo Bypass capacity at Interstate 80 and the Southern Pacific RR Tracks (Figure 5). This alternative could include:

1. Removing some or all of the embankment material under both the highway and railroad systems and replacing it with bridge structures.

Alternative F: Any and all combination of the above.

EXISTING RESOURCES

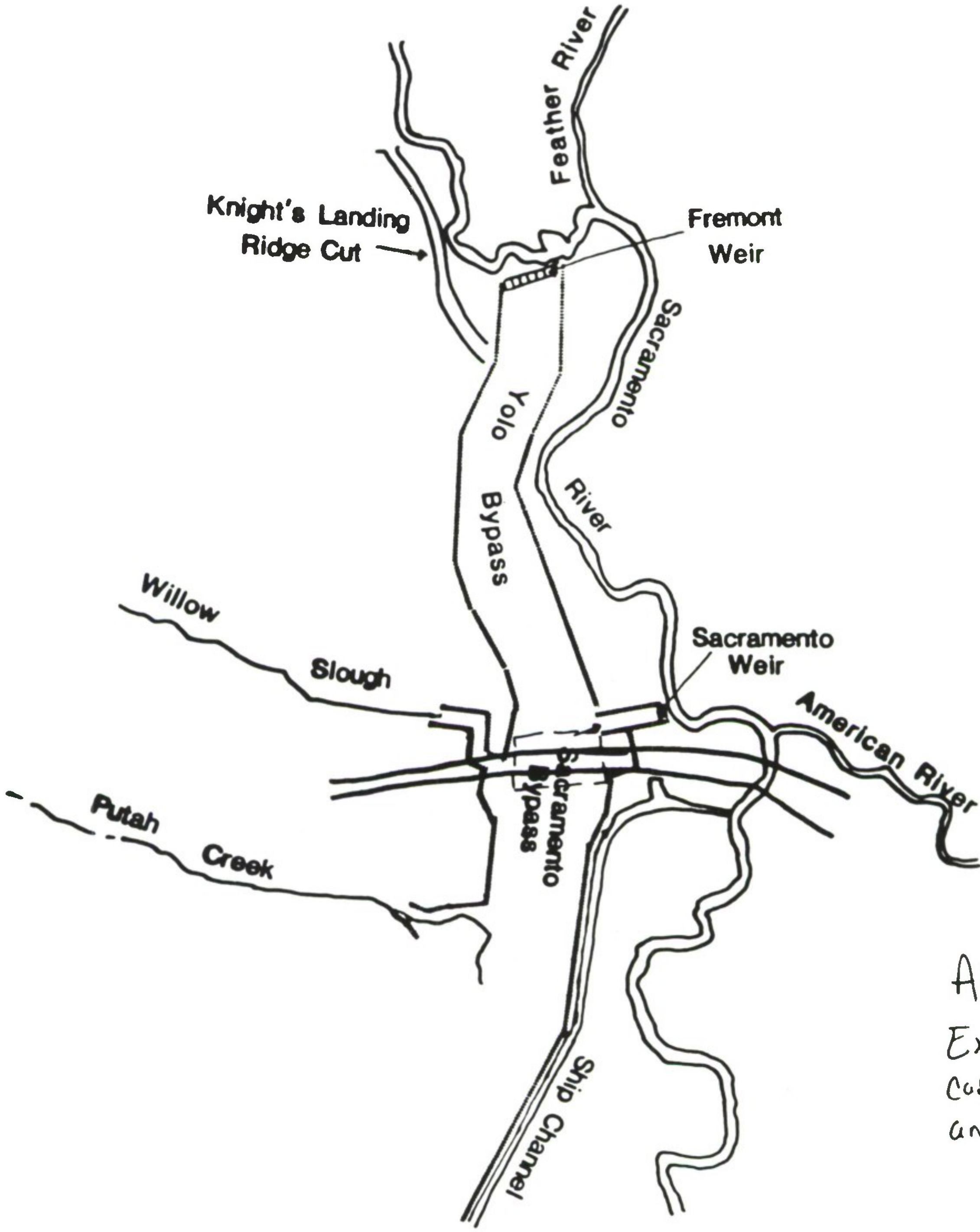
Aquatic Resources [1/]

Most of the high value anadromous and resident sport fish species present in the Sacramento River also frequent the Sacramento River Deep Water Ship Channel. Year-round access into the Ship Channel is provided via the Sacramento River through Cache Slough. Similarly many of the other non-game species present in the Sacramento River are also found in the Ship Channel.

The more important anadromous sport species include chinook salmon, steelhead, green and white sturgeon, striped bass, and American shad. Resident game species of importance include white and channel catfish, brown bullhead, and a variety of sunfish including black bass, black crappie, and bluegill.

The same anadromous fish species identified in the Ship Channel are also occasionally present in several of the borrow ditches within the Yolo Bypass such as the Tule Canal and Knights Landing Ridge Cut. Some of the borrow ditches adjacent to the levees support a significant warmwater fishery consisting of black bass, crappie, catfish and bluegill. Several nongame fish such as carp, suckers, minnows, and mosquitofish are also present.

[1/] Much of the following descriptive information about fish species was taken from the Final Environmental Impact Report and Supplemental Environmental Impact Statement on the Sacramento Bank Protection Project (Jones and Stokes, 1987) and from the Sacramento River Deep Water Ship Channel, California Feasibility Report and Environmental Impact Statement for Navigation and Related Purposes (CE, Sacramento, 1980).



Alternative E
Expand Yolo Bypass
capacity at I-80
and SPRR tracks

Figure 5

Most of the species previously identified (game and nongame) that are present in the Sacramento River may enter the Yolo Bypass during storm events. There is little information available on fish population levels, habitat conditions, and sportfishing effort and success in the Ship Channel, Yolo Bypass, and borrow ditches and canals within the Yolo Bypass. The reference on bank protection (Jones and Stokes, 1987) appears to have the best discussion on life histories of fish species found in the project area.

The Sacramento River provides important habitat for an abundant and diverse anadromous and resident fish population. Four races of chinook salmon, steelhead trout, striped bass, American shad, and green and white sturgeon comprise the anadromous coldwater game fish that occur in the project area. Resident coldwater game fish include rainbow and brown trout. Resident warmwater game fish include largemouth bass, white crappie, black crappie, channel catfish, white catfish, brown bullhead, yellow bullhead, bluegill, and green sunfish. Native nongame fish such as the Sacramento perch and tule perch are present in relatively low numbers, whereas the Sacramento squawfish and Sacramento sucker are abundant.

Chinook salmon are considered the most important fish for commercial and sportfishing interests in California. The Sacramento River sustains the largest chinook salmon run in California, as over 90 percent of the Central Valley salmon population spawn in the Sacramento River system (Kjelson et al. 1982). It is estimated that about one-half of the current average total spawning escapement occurs in the lower Sacramento River system (including the confluence of the Feather River and downstream). Chinook salmon are present in the project area during the fall through spring primarily during migration periods. The fall-run chinook is the most abundant race, comprising about 90 percent of the Sacramento River Basin stock (Hallock 1987). All other races of chinook salmon in the Sacramento River Basin have declined in recent years. The most serious decline has been in the winter-run race where annual spawning escapement counts at Red Bluff Diversion Dam have dwindled from a high of 117,000 in 1969 to less than 4,000 since 1982.

Several agencies and groups including the California Department of Fish and Game, California Department of Water Resources, National Marine Fisheries Service, U.S. Army Corps of Engineers, U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service, California Advisory Committee on Salmon and Steelhead Trout and others are cooperating in a special action program to halt the decline of salmon stocks and to restore the winter-run race.

Steelhead trout are also present in the upper Sacramento River year-around and in the project area from fall through spring during migration periods. Spawning and rearing are primarily confined to tributary streams. Steelhead populations in the lower Sacramento tributaries such as the Feather, Yuba and American Rivers have remained relatively stable. In contrast, steelhead populations in the upper Sacramento River have declined from more than 20,000 in the late 1950's to less than 5,000 in the 1980's (Hallock 1987).

Striped Bass. Adult striped bass are found in the Sacramento River only during spawning runs from April to June. Most spawning occurs between Isleton (RM 17) and Butte City (RM 169). The semi-buoyant eggs and larvae are carried downstream near the bottom and mid-channel into the Delta and Suisun Bay. Most eggs hatch between Courtland (RM 34) and Sacramento (RM 60). Larvae and juveniles tend to concentrate near the shoreline. During their second year, young bass may move back upstream from the Delta into the Sacramento River.

American Shad. American shad are similar to striped bass in their use of the Sacramento River. Adult fish are present only from April to June during spawning. Spawning occurs in the Sacramento River above Hood (RM 38) and in the tributaries. Semi-buoyant eggs gradually drift downstream before hatching. Some newly hatched shad begin downstream migration immediately, while others remain near spawning areas until they reach about 75 mm in length. Juvenile shad are common in the Sacramento River from July through November during a protracted out-migration period. Larvae and young juveniles occur in greatest abundance in the Sacramento River from Freeport (RM 46) downstream. Juvenile shad appear to favor the inside of river bends or sandy bars.

White and Green Sturgeon. Adult sturgeon are found in the Sacramento River from March to June during spawning migrations. White sturgeon are believed to migrate farther upstream than green sturgeon. The adhesive eggs stick to the substrate after fertilization. Larvae stay close to the bottom after hatching and are washed downstream into the estuary.

Most warmwater game species prefer quiet, backwater areas and nest on the bottom. These fish seldom inhabit the main channel where current velocities can be high and cover lacking. Warmwater game species spend their entire life cycle in the Sacramento River and do not undertake spawning migrations. Most species prefer shoreline areas along natural, vegetated levees. Heavily-shaded riverine aquatic habitat provides essential spawning cover for sunfish and channel catfish in particular.

Terrestrial Resources[2/]

There are many significant and diverse types of terrestrial habitat within the project area which support wildlife populations. However, conversion of native habitat to agriculture and urban uses has accelerated wildlife population declines. In some cases, the populations have been impacted so greatly that they are listed as threatened or endangered, or are candidates for listing.

[2/] The following description of habitat types are based on field inspections and consultation with California Department of Fish and Game biologists, discussions with Fish and Wildlife Service biologists familiar with the project area and habitat descriptions cited in the Final Environmental Impact Statement IV for the Sacramento River Bank Protection Project (Jones and Stokes, 1987).

Valley grassland. This habitat is typically comprised of primarily non-native grasses such as wild oats, bromes, foxtails, needlegrass, bluegrass, triple-awned grass, fescue, and forbs including California buttercup, California poppy, curly dock, lupines, clover, milkweed, yellow star thistle, California goldenrod and others.

Only a few significant large parcels of valley grassland remain intact in the project area. Most of the upland areas that support valley grassland vegetation have been converted to agricultural uses. There are several acres of valley grassland interspersed with valley oak woodland, forested wetlands, and shrub scrub wetland within the first mile of the Yolo Bypass below the Fremont Weir. Because this area is being managed for wildlife, the grassland vegetation has remained relatively undisturbed. Additional detailed aerial photo review and/or onsite field investigation will be required to determine specific distribution of this habitat.

By itself, the valley grassland habitat supports fewer wildlife species compared to riparian or oak woodland habitats. However, when interspersed with either riparian or oak woodland, it supports a much greater and diverse wildlife community. Wildlife species typically found in the valley grassland include coyote, black-tailed jackrabbit, kangaroo rat, valley pocket gopher, desert cottontail, striped skunk, raccoon, California mole, ring-necked pheasant, kestrel, white tailed kite, prairie falcon, short-eared owl, mourning dove, western meadowlark, red-tailed hawk, American goldfinch, and gopher snake.

Valley oak woodland. Valley oak stands typically occur away from the river channel with a discontinuous canopy typically mixed with an understory of valley grassland community species. This habitat occurs in the valley floor generally at elevations less than 400 feet. There are also very few large parcels of this habitat remaining in the project area. As with the valley grassland, the most notable parcels of valley oak woodland are located within the first few miles below the Fremont Weir in the Yolo Bypass. There are others adjacent to the south cross levee and near the juncture of several small drainages such as Babel Slough where they intersect the Sacramento River Deep Water Ship Channel. Common wildlife species occurring in the habitat include the raccoon, badger, striped skunk, coyote, gray fox, western gray squirrel, black-tailed jack rabbit, desert cottontail, harvest mouse, turkey vulture, red-tailed hawk, rough-legged hawk, kestrel, Swainsons hawk, mourning dove, great horned owl, common flicker, Lewis' woodpecker, western kingbird, scrub jay, white breasted nuthatch, lark sparrow, Pacific gopher snake, common kingsnake, and northern Pacific rattlesnake.

Willow scrub. This habitat occurs in disturbed moist areas such as flood flow aggradation and levee berms. There are also very few large parcels of this habitat remaining in the project area. Reduced lateral erosion and channel meandering caused by channelization have contributed to a decline in willow scrub habitat in the leveed portion of the Sacramento River and Yolo Bypass. There is little of this habitat along the Sacramento River

channel and Yolo Bypass below Sacramento. Some willow scrub habitat is present in the Yolo Bypass Channel and along levee berms downstream of Fremont Weir, in the Sacramento Bypass Channel, and along waterward levee berms of the Sacramento River Deep Water Ship Channel.

The willow scrub habitat provides a variety of conditions important to wildlife species. Because the vegetation is dense, it provides cover for many wildlife species. Beavers preferentially feed on young willow shoots, and many small birds and mammals feed on willow seeds.

Willows support an abundance of insect prey that feed on fresh foliage and stems during the growing season. These insects, in turn, support a high density and diversity of migratory and resident insectivorous birds. Birds that often use this habitat include the western flycatcher, yellow warbler, Macgillivray's warbler, Wilson's warbler, and song sparrow.

A number of species that formerly nested in the Sacramento Valley used this habitat. The least Bell's vireo is most notable in this regard; it was once very abundant, but no longer nests in northern California. Similarly, the California yellow-billed cuckoo, which nests almost exclusively in dense, older willow stands, may be limited in some otherwise suitable areas by a lack of nesting habitat (Laymon and Halterman 1985). (See "<u>Threatened and Endangered Species</u>" below).

Other former breeding species that have declined or been eliminated from the valley floor include the willow flycatcher, yellow warbler, and yellow-breasted chat (Remsen, 1978). Many of these species now occur only during migration periods. Causes for their decline include a reduction in the amount of habitat and cowbird parasitism.

<u>Mixed riparian forest</u>. This habitat occurs adjacent to water courses. There are significant stands of mixed riparian forest along the right bank of the Sacramento River upstream and downstream of the Fremont Weir, along the Old River channel, at the south end of Knights Landing Ridge Cut, about 2 1/2 miles from the north end of the Tule Canal, about 2 miles along the Tule Canal north of the Sacramento Bypass, within the Sacramento Bypass along the north side of its levee, adjacent to the south cross levee and near the junctures of Babel Slough and Arcade with the Sacramento River Deep Water Ship Channel. It may include a variety of tree, shrub, and ground cover plant species such as cottonwood, alder, willow, popular, box elder, oak, elderberry, blackberry, wild grape, poison oak, wild rose with mixed grass and forbs. The diversity of plant species and manner of growth provides a variety of food, cover and reproductive opportunities for many wildlife species. This habitat supports the most abundant and diverse wildlife species assemblage along the Sacramento River and nearby waterways. Oaks, walnuts and other mast producing trees support species such as acorn woodpecker, Lewis' woodpecker, common flicker, Stellers jay, plain titmouse, deer mouse, and the western gray squirrel. The mixture of tree species and density provide an increased cover element for larger

fauna such as the mule deer, gray fox, striped skunk, and raccoon. Raptors such as the osprey, red-tailed hawk, red-shouldered hawk, and Swainson's hawk find suitable perch and nest sites in the habitat.

A variety of other avian species including Nuttall's woodpecker, northern oriole, great horned owl, belted kingfisher, western flycatcher, black phoebe, common crown, and the brown creeper are also found in the riparian forest.

Vertical Banks. These habitat areas are created by river erosion or bank sloughing and are more common along the riverbanks of the upper Sacramento River where the banks are unleveed. It is unlikely that significant vertical bank habitat exists in the Yolo Bypass. There may be some in the Old River Channel. Several locations of vertical bank were identified along the Sacramento River from the confluence of the Natomas Cross Canal (River mile 79) to the confluence of the American River (River mile 60.5). No vertical banks were seen along the Sacramento River Deep Water Ship Channel levees. Vertical banks are often identified as priority sites for bank protection activity creating potential resource conflict.

A few avian species are dependent on vertical banks for reproduction activity. These are the bank swallow, the rough-winged swallow, and the belted kingfisher. There are also a few other species (e.g., barn owl, cliff swallow and black phoebe) which use vertical banks but are not solely dependent on them for reproduction.

Heavily-Shaded Riverine Aquatic (HSRA). This habitat is a special category requiring a combination of a dense canopy of woody riparian vegetation that overhangs the water and provides complete shade cover during a significant portion of the day. Other typical characteristics of this habitat type are: (1) living roots, branches, or trunks of woody plants exposed within the water; (2) fallen plant material including logs, branches, leaves and other detritus within the water; (3) uneven banks with many depressions, cavities, and crevices; (4) shallow nearshore areas; and (5) a substantially higher primary food production and lower water temperatures for aquatic organisms than nearby unshaded aquatic areas. In many areas, it may be considered an unique and irreplaceable habitat. It is always considered a high value habitat for fish and wildlife species.

Most of the HSRA occurring on the Sacramento River within the project area has been identified. The location, areal coverage, and overall habitat value of HSRA from Freeport (River mile 46) to Sacramento (River mile 58.8) were recently mapped by Fish and Wildlife Service (FWS) personnel (FWS, 1987). Similar information for the reach from Sacramento (River Mile 58.8) to the confluence of the Natomas Cross Canal south of Verona (River mile 79) was collected by FWS personnel this year (unpublished, FWS, 1988). Although these surveys indicate that HSRA is not abundant along these reaches of the Sacramento River, nevertheless there are significant amounts that provide valuable instream habitat. It is apparent that levee construction and maintenance have greatly reduced HSRA abundance along these reaches of the Sacramento River. Based on our observations, it is

likely there are significant amounts of this habitat along the Tule Canal, the Old River Channel, at the south end of Knights Landing Ridge Cut, along the West Yolo Bypass levee toe drain beginning near Willow Slough, along the South Fork of Putah Creek, at the west end of the Willow Slough Bypass where it flows into the Yolo Bypass, along the toe drain that parallels the east side of the Yolo Bypass levee, at the confluence of drainage canals and the Sacramento River Deep Water Ship Channel near Arcade, and at the confluence of Babel Slough and the Sacramento River Deep Water Ship Channel. More detailed observations and additional mapping of HSRA will be needed during the feasibility stage of investigation.

Species supported by this habitat include primarily aquatic species which benefit from the special conditions provided, such as cooler water temperatures than surrounding areas, improved cover due to shading effect, protection from some avian predators, increased niches for hiding under tree root wads, downed logs and overhanging vines, improved opportunity to capture insects from overhanging vegetation, and increased protection from high flows. Included are several coldwater gamefish such as juvenile salmon, striped bass, steelhead, and American shad, and several warmwater gamefish including sunfish and catfish. Avian species include the belted kingfisher, great blue heron, green-backed heron, black-crowned night heron, great egret, red-winged blackbird, rufus-sided towhee, American goldfinch, Pacific tree frog, and the Sierra garter snake.

Freshwater Marsh. Freshwater marshes are seasonally or permanently water-filled depressions, generally less than five feet in depth with established submerged and emergent herbaceous vegetation in and surrounding the water. Common plant species are sedges, bulrushes, pondweeds, willows, and cattails. There are numerous areas within the project study area which have been identified as freshwater marsh. They were mapped by the Fish and Wildlife Service in their National Wetlands Inventory (Inventory) of Wetlands and Deepwater Habitat (FWS, 1979). Due to the minimal time afforded for our field review, we relied on the Service's Inventory maps for freshwater marsh locations. On site review will be needed in feasibility level planning to update and verify the location and sizes of these freshwater marshes.

Since there are so many of these freshwater marsh areas, we have confined our discussion to those location adjacent to the proposed construction areas. There are approximately 8 acres of freshwater marsh adjacent to the northeast end of the Old River Channel near the Fremont Weir. There are several linear miles of freshwater marsh habitat along the margin of the Tule Canal south of the Interstate 5 crossing, and at least 50 acres or more within the 3 miles of Yolo Bypass south of the Interstate 5 crossing. There are several freshwater marsh areas along the west side of the Yolo Bypass within the first 2 miles south of the Interstate 5 crossing. Within the Sacramento Bypass, there are about 3 acres of freshwater marsh located at the west end near the north levee, and some freshwater marsh midway along the south levee. There are at least 14 acres of freshwater marsh located along the channel side of the Sacramento River Deep Water Ship Channel west Levee more than 1/2 mile south of the proposed pumping

facility site. There is also some freshwater marsh identified on the west side of the turning basin in the Sacramento River Deep Water Ship Channel. Freshwater marsh habitats are especially important because they support abundant and diverse wildlife species, rare plant species, and are relatively scarce in the study area. Freshwater marshes provide cover, nesting and forage habitat for such wildlife species as herons, egrets, bitterns, marsh hawks, red-winged blackbird, Pacific tree frog, marsh wren, muskrat, and garter snake.

Threatened and Endangered Species

Our Sacramento Endangered Species staff provided, on June 17, 1988, a letter with their latest information on Federally-listed species in the project area. At this time, we have no new information concerning endangered or threatened species. We have included a brief summary of their June 17 letter and appended a copy to this report (Appendix 1). To the best of their knowledge, our Endangered Species staff indicates that there were no proposed species within the project area. However, the threatened valley elderberry longhorn beetle as well as several candidate species, the Sacramento perch (Sacramento valley population), California hibiscus, and Sacramento splittail may be present in or adjacent to the Yolo and Sacramento Bypasses and the Sacramento River Deep Water Ship Channel. Upon completion of your biological assessment, if it is determined that the listed valley elderberry longhorn beetle may be affected by the project (adversely or beneficially), your agency should request formal Section 7 consultation pursuant to 50 CFR § 402.14 through our Endangered Species staff.

Following are species listed as threatened or endangered by the State of California.

Species	Status
Giant garter snake *Thamnophis couchi gigas*	threatened
Swainson's hawk *Buteo-swainsoni*	threatened
Western yellow-billed cuckoo *Coccybus americanus occidentalis*	threatened
Ferris' bird's-beak *Cordylanthus palmatus*	endangered

FUTURE CONDITIONS WITHOUT THE PROJECT

Aquatic Resources

Under without project conditions, the status of aquatic resources in the Sacramento River, Yolo and Sacramento Bypasses, and Sacramento River Deep Water Ship Channel will largely depend on actions of Federal and State permitting agencies and maintenance practices of reclamation districts. Aquatic resources in the Sacramento River could experience drastic declines unless agencies granting development permits such as the U.S. Army Corps of Engineers and California State Water Resources Control Board act to

maintain the existing levels of these resources. According to the U.S. Bureau of Reclamation, predicted future demands for diversion of water from the Sacramento River for agricultural, municipal and industrial purposes will cause major problems for fish stocks by the year 2020 (USBR, 1986). Pumping, unscreened diversions and reduced flow would exacerbate ongoing losses due to entrainment, impingement, dewatering of spawning redds, mining pollution, degraded spawning and rearing habitats, unsuitable water temperatures, and degraded migratory corridor conditions for anadromous and resident fish. Aquatic resources in the Yolo and Sacramento Bypasses and Sacramento River Deep Water Ship Channel will probably remain at about the same level if flood control (reclamation district maintenance) and farming activities remain the same.

The success of cooperative efforts by the California Department of Fish and Game, U.S. Fish and Wildlife Service, National Marine Fisheries Service, and other sportfishing interests to protect and restore anadromous stocks in the Sacramento River will partially be determined by the actions of regulatory agencies such as the U.S. Army Corps of Engineers and the California State Water Resources Control Board. By incorporating appropriate fish protection and water quality control measures in Section 10 and 404 permits, these agencies could assist in anadromous stock protection and restoration.

Angling, swimming, recreational boating, and demands for facilities will likely increase due to increased in urban population in and adjacent to the project area. This will place a greater strain on remaining resources and the agencies charged with protecting them.

Terrestrial Resources

Under without project conditions, the abundance of terrestrial wildlife resources in the project area will continue declining at some undetermined rate unless the regulatory agencies and reclamation districts focus more emphasis on wildlife habitat protection and enhancement. Vertical bank, willow scrub, and riparian habitat losses from bank stabilization and levee maintenance programs will continue to exacerbate wildlife habitat losses. Mitigation measures recommended by the conservation agencies will offset only some of the habitat losses.

IMPACTS OF ALTERNATIVES

The following assessment of potential project alternative impacts is preliminary in nature and somewhat general due to the absence of specific project details. For a more detailed impact analysis, we will need specific information on project boundaries, proposed construction methods, timing of work and operational methods. Also, field studies must be conducted to determine baseline resource information, and to provide a more accurate assessment of expected impacts with each alternative.

ALTERNATIVE A: Allow more flow over Fremont Weir.

Option 1. Remove Sediment from eight miles of the Yolo Bypass.

Aquatic. Excavation in the Yolo Bypass Channel, without final grading provisions, could exacerbate problems of adult and juvenile fish stranding in isolated pools. Under existing conditions, there are many isolated pools which act as fish traps as floodwaters recede in the Yolo Bypass. There are no provisions for fish escapement during flood recession such as graded channels or waterways leading out of the bypass.

Terrestrial. Under a worst case analysis, removal of all excess sediment deposited within the upper eight miles of the Yolo Bypass would result in excavation activity on many acres of established valley oak woodland, valley grassland, some willow scrub, mixed riparian forest, freshwater marsh, and other permanent and seasonal wetlands. Practically all of wildlife values associated with these habitats would be lost for varying periods depending on future maintenance requirements. The following estimated area losses are based on excavation of practically all of the excess deposited sediments from the east Yolo Bypass levee to west Yolo Bypass levee (1.5 miles average width) beginning at Fremont Weir and continuing 8 miles downstream. About 9,000 acres of upland including the valley grassland and valley oak woodland habitats would be lost. About 1,000 acres of wetlands including 200 acres of open waters, 200 acres of palustrine forested wetland, 400 acres of palustrine scrub/shrub wetland, and 100 acres of palustrine emergent wetland would also be lost. Selective clearing within the Yolo Bypass would greatly reduce the habitat losses described above.

Much of the forested wetlands, e.g., mixed riparian forest habitat that would be affected, are located along the Old River channel below the Fremont Weir, near the terminus of the Knights Landing Ridge Cut, and along the Tule Canal. Most of the scrub-shrub wetlands, valley grassland, valley oak woodland, and willow scrub are located within the first mile of the Yolo Bypass below the Fremont Weir. As previously stated, some of this area above and below the Fremont Weir is designated as wildlife management area administered by the California Department of Fish and Game. There are also some private lands within one mile downstream of the Fremont Weir being managed under State of California wildlife refuge guidelines. Practically all of the remaining seven miles of lands in the Yolo Bypass below the Fremont Weir are farmed. Much of the adverse impacts in these seven miles would be to the unfarmed emergent and scrub-shrub wetlands located along the ditches, canals, waterways, and levee berms. However, there are also wildlife values associated with many of the farm crops such as rice and grain which may be adversely affected by this alternative.

Although it is true that if permitted, natural revegetation will occur over time, mature trees valuable to wildlife such as oak, sycamore, cottonwood and others would take many years to regrow. In the interim, habitat value

would be lost for those species requiring mature trees such as squirrels, wood ducks, and raptors. The average value of habitat over the long-term would depend on frequency of maintenance excavation in the Yolo Bypass.

<u>Option 2</u>. Modify the elevation of the Fremont Weir Crest.

~~Increase volume not duration~~

<u>Aquatic</u>. Increasing the length, frequency, and amount of Sacramento River water diverted into the Yolo Bypass during December through March (flood season) will likely increase the loss of anadromous fish due to stranding, predation, failure to emigrate, and other stresses. The extent of losses will depend on whether the length and timing of flooding events coincide with anadromous fish migration. In a worst case, frequent flood water diversion and recession would occur during peak fish migration periods.

<u>Terrestrial</u>. Lowering the elevation of the Fremont Weir crest without addition of gated control would effectively increase the frequency and length of time that water is present in the Yolo Bypass. Many of the upland tree species such as the oaks are sensitive to inundation and will die if inundation is prolonged. Without more information on hydrology of flood periods, it is difficult to estimate the severity of adverse impacts on sensitive vegetation. Lengthening the period of inundation in the Yolo Bypass would also shorten the farming season which could be beneficial for some wildlife. This would lengthen the available period that wintering migratory and resident waterfowl could use the Yolo Bypass for resting and feeding activities. However, conversely it would decrease the habitat availability for some terrestrial species; for example, it would decrease availability of forage area and prey for carnivores and raptors.

<u>Option 3</u>. Setting back the levees of the Yolo Bypass along an eight mile reach.

<u>Aquatic</u>. Without appropriate plans to retain and protect existing aquatic habitat values, adverse impacts would occur with setback levees. There are significant aquatic resources including warmwater fish, crayfish, waterfowl, and other fauna present in the toe drains, borrow ditches, and waterways adjacent to the levees. There is also a low level of sport fishing activity which could be permanently or temporarily lost with levee setback. The level of adverse impact would depend on plans for existing levees, canals, toe drainage modifications, and construction timing.

<u>Terrestrial</u>. Similarly, as stated above, setting back both the east and west Yolo Bypass levees without plans to retain and protect existing terrestrial habitat values would cause significant adverse impacts. The extent of these impacts would depend on the plans for retention or removal of existing levees, location and manner of construction of new levees, and timing of the work. Adverse impacts could be reduced by constructing only one setback levee, retaining the existing levees and their associated borrow ditches or toe drains, and adhering to construction methods and timing which are least damaging to wildlife habitat.

Loss of (1) mixed riparian forest along the Tule Canal, (2) wetland scrub-shrub near the Knights Landing Ridge cut, and (3) scrub-shrub along the existing toe drains adjacent to both levees, during levee removal or new levee construction, would cause major impacts to fish and wildlife. The greatest terrestrial habitat loss would occur with destruction of very old and tall tree species (oaks, cottonwood and willows), and loss of established riparian communities along existing waterways. Again, setting back only one levee and reducing the length of levee being setback would greatly reduce terrestrial resource impacts. Levee setback of the West Yolo Bypass levee could cause significant loss of scrub-shrub wetlands located on the west side of the levee. These wetlands are relatively small in size (1-3 acres), but provide important habitat for many wildlife species. These wetlands appear to be unfarmed due to a water soils regime that is unsuitable for farming.

Option 4. Any Combination of Options 1-3.

Aquatic and Terrestrial. Based on the previous discussion of impacts, implementing all three options, e.g., sediment removal, lowering the Fremont Weir crest, and setting back both levees without special provisions, would result in the greatest impacts. A no action alternative would be the least adverse and any other combinations would fall somewhere between. Further discussion of the relative impacts, mitigation, and enhancement for these Alternative A options is included in the section that follows on acceptability of alternatives.

ALTERNATIVE B. Modify the Sacramento Weir.

Option 1. Modify operation of the gates.

Aquatic. Modifying the operation of the gates at the Sacramento Weir to improve flow control could increase, decrease, or have no impact on aquatic resources depending on gate operations. Increasing the length of the diversion period would increase fish losses due to entrainment, stranding, and probably increased predation in the Yolo Bypass, thereby reducing migratory fish survival. Increasing velocity into the Sacramento Bypass and/or the ratio of diverted water to flow in the Sacramento River could also increase fish losses.

Terrestrial. Increased flow velocities through the Sacramento Bypass could conceivably increase erosion and vegetation loss. Conversely, decreased average flow velocities during a storm could reduce erosion and loss of vegetation. There are several acres of willow scrub habitat within the Sacramento Bypass near the south east portion of the south levee, and several acres of mixed riparian forest near the northwest portion of the north levee which could be impacted with modified gate operation.

Option 2. Modify the Sacramento Bypass and Weir to increase capacity.

Aquatic. Modifying the Sacramento Bypass and Weir to increase capacity could cause similar aquatic impacts as with Option 1 above. Increasing the

capacity of the Sacramento Bypass thereby increasing amount of water diverted during flood events would increase chances for fish losses in the Yolo Bypass as described. However, without more detailed fishery studies, it would be difficult to determine which modification, e.g., lowering or widening the weir, causes the greatest fish losses.

Terrestrial. Modifying the Sacramento Bypass and Weir to increase capacity could cause similar impacts to terrestrial resources as in Option 1. Increasing the length of inundation period and velocity of water in the channel could increase erosion and vegetation losses in the channel and on the levee berms. Impacts due to widening of the channel would depend on levee construction plans and timing of construction.

There are several acres of willow scrub and mixed riparian forest habitat at the north end of the Sacramento Weir which would be lost with construction. Other areas, most of the north end, consists of uplands with grasses and scattered brush. Similar habitat is present on the southeast end of the Weir. Eliminating the gates and making a permanent weir would reduce control of flows within the Sacramento Bypass and could increase vegetation impacts.

Option 3. Remove sediment from the Sacramento Bypass both upstream and downstream of the Sacramento Weir.

Aquatic[3/]. There are approximately 20 surface acres of ponded open water adjacent to the channel side of the levees within the Sacramento Bypass. Excavation of the channel bed would alter these wetland areas.

Terrestrial. Excavation of all sediment in the 400 acre channel bed would adversely impact about 385 acres of upland and several acres of scrub-shrub and mixed riparian wetlands. Abundant wildlife are present in the established scrub-shrub and mixed riparian habitat. Excavation of the channel area immediately upstream and downstream of the weir would have minimal impact on vegetation important to wildlife.

Option 4. Setback levees along the Sacramento Bypass.

Aquatic. Setting back the north levee would probably cause less aquatic impacts than setting back the south levee.

There are about 7 acres of open water surrounded by mixed riparian forest on the south west portion landward side of the south levee. There are mainly farmed lands of mixed hay and grain and tomatoes landward of the north levee.

3/ The 20 acre figure includes the portion of the Tule Canal at the west end of the Sacramento Bypass.

Terrestrial. As stated above, setting back the north levee also would cause less impacts to terrestrial resources. There would be minimal impacts on wetland vegetation on the north side, whereas major impacts to the mixed riparian forest could occur if the south levee were setback.

Retention of the existing north and south levees and construction of new setback north levee could minimize adverse impacts to aquatic and terrestrial resources and possibly enhance these resources.

Aquatic and Terrestrial. A combination of modifying the Sacramento Bypass and Weir to increase flow capacity, removing sediment from the Bypass, and setting back both levees would cause the greatest impacts to fish and wildlife. However, modifying the Sacramento Weir gates could benefit fish and wildlife if the gates were operated to protect existing habitat.

ALTERNATIVE C: Use of Sacramento River Deepwater Ship Channel (Ship Channel)

Option 1. Construct additional levees around the Sacramento River Deep Water Ship Channel and Port of Sacramento facility, and pump water from the Yolo Bypass or Sacramento River into the Sacramento River Deep Water Ship Channel.

Aquatic. Construction of additional levees around Sacramento River Deep Water Ship Channel and Port of Sacramento facilities, and a pumping plant near the ship channel to pump water into the ship channel from either the Sacramento River or Yolo Bypass could cause significant impact to aquatic resources. Pumping large volumes of water will increase entrainment, impingement, and mortality of all types of fish. Further studies would be needed to evaluate fish species and numbers that would be affected by pumping during storms and high flow periods.

Terrestrial. Construction of a pumping facility and levees around the Sacramento River Deep Water Ship Channel and Port of Sacramento facilities could cause some loss of scrub shrub and emergent wetland vegetation along the edge of the ship channel. Existing levee berms are primarily covered with grasses and shrubs. There would probably be minor impacts to upland habitat on these berms as long as the few scattered mature, old age, cottonwood trees along the levee crown are not disturbed. Raising water levels in the ship channel for extended periods may have an adverse impact on the wetland vegetation growing along the water's edge. The extent of vegetation loss would depend on exact size and location of pumping facility, additional levee construction plans, and the extent of increased inundation within the ship channel.

ALTERNATIVE D: Levee modifications along the Sacramento River around West Sacramento, east Yolo Bypass levees, and the south cross levee near River view.

Aquatic. Raising the right (west) Sacramento River levee in the Raley's Landing area near "I" Street could probably be accomplished with minimal

aquatic resource impacts. The level of adverse impact would depend on levee and construction methods. With an appropriate fishery construction window (July 1 - September 30 and adherence to California Regional Water Quality Control Board discharge criteria) impacts should be slight.

The level of impact associated with widening and raising about 6 miles of the west Yolo Bypass levee, beginning at the Sacramento Bypass and extending down to the south cross levee, will also depend on levee design and construction methods. The proposal to widen the levee landward is preferable to widening it toward the Yolo Bypass Channel side, because it will reduce impacts to existing waterways such as the toe drain that parallels the west levee. Planning efforts to minimize construction near the toe drain and complying with Regional Water Quality Control Board discharge permit criteria permit should greatly reduce any adverse aquatic resource impacts.

Raising the west Yolo Bypass levee to compensate for east Yolo Bypass levee changes could also cause significant aquatic habitat impacts. There are over 100 surface acres of open water habitat on the channel side of the west Yolo Bypass levees. There are also many acres of scrub-shrub and emergent wetland habitat associated with these waterways on the channel side. Raising the west Yolo Bypass levee on the landward side and adhering to Regional Water Control Board discharge permit criteria would greatly reduce potential adverse aquatic resource impacts.

Terrestrial. There will be significant adverse impacts on terrestrial resources with any levee construction in the vicinity of Raley's Landing. There are many mature riparian tree species such as cottonwood and willow growing landward, on the waterside, and along the crown of the levee. Environmental consideration in levee design, careful planning of construction activities to minimize damage to these mature trees, and revegetation would greatly diminish adverse impacts.

Raising and widening the west Yolo Bypass levee landward rather than on the waterside should reduce terrestrial resource impacts. Much of the area landward from the levee is upland which is farmed or developed (industrial use). Planning of levee design and construction activities to minimize impacts on scrub-shrub and mixed riparian habitat at the confluence of the Sacramento Bypass and the west Yolo Bypass levee, and the juncture of the toe drain and the west Yolo Bypass levee near I-80 could reduce adverse impacts. Similarly, appropriate planning to protect emergent wetland areas located along the east Yolo Bypass levee and the channel margins of the Sacramento River Deep Ship Channel would reduce adverse terrestrial impacts.

Raising and widening the south cross levee on the landward side and to the north could cause some adverse impacts to scrub-shrub habitat located along the two acre waterway which parallels the north side of the levee. However, widening to the north rather than the south is preferred because a

much larger (12 acre) waterway exists south of the south cross levee. Planning and construction activity should be designed to minimize damage to scrub-shrub and mixed riparian habitat.

ALTERNATIVE E: Expand Yolo Bypass capacity at Interstate 80 causeway and the Southern Pacific Railroad Bridge.

Aquatic. Flow capacity could be improved with better coordination of the embankment placement. On our site review, we noted that frequently the embankment supporting the railroad bridge was directly upstream of an opening under the Yolo Causeway, and conversely an opening under the railroad bridge was just upstream of an embankment supporting the causeway. This lack of a consistent flow through pattern under the railroad bridge and causeway would likely retard flood flows. Although no data is available, it seems likely that fish passage conditions under the railroad bridge and Yolo Causeway would be improved with this alternative.

Terrestrial. Removal of embankment material under the Yolo Bypass causeway or the Southern Pacific Railroad Bridge to increase Yolo Bypass flow capacity would likely cause minimal terrestrial resource impacts. Much of the area is farmed or degraded due to railroad maintenance activities; terrestrial resource values appear to be minimal.

SUMMARY

All of the alternatives presently under investigation will have some impact on the abundant and diverse aquatic and terrestrial resources within the study area. Some of the study alternatives would cause serious adverse environmental impacts that would be difficult to mitigate, i.e., pumping or diversion of waters into the Sacramento River Deep Water Ship Channel. While other study alternatives (such as the Yolo Bypass levee widening) would be more desirable for implementation because of favorable mitigation and enhancement opportunities they present. The following discusses the acceptability of the proposed alternatives, and mitigation and enhancement opportunities for each alternative.

ACCEPTABILITY OF THE ALTERNATIVES FROM A FISH AND WILDLIFE PERSPECTIVE

Based on the above discussion of the alternatives and their probable impacts, we rated the alternatives according to acceptability from a fish and wildlife resource viewpoint (Table 1). The ratings take into account potential mitigation and enhancement opportunities of each alternative. We included with and without mitigation ratings of each alternative (all options included), and then included a separate rating of each option within the alternatives. As shown, the options which involve sediment removal in the Yolo and Sacramento Bypasses are not acceptable even with mitigative measures. Those options which include (1) modification of the Fremont Weir crest, (2) setback of Yolo and Sacramento Bypass levees, (3) modifying the Sacramento Weir gate control and expanding the Yolo Bypass

levees, and (4) modifying the Sacramento Weir gate control and expanding the Yolo Bypass capacity at the Yolo Causeway and Southern Pacific Railroad Tracks would be acceptable with appropriate mitigation measures.

TABLE 1. ALTERNATIVES ACCEPTABILITY RATING

	Low	Med	High
<u>Whole Alternatives</u>			
Without mitigation	A,B,C,D	E	
With mitigation	C	A,B,D	E
<u>Options Within Alternatives</u>			
Without mitigation	A_1,A_2,A_3,A_4		E_1
Without mitigation	B_1,B_2,B_3,B_4,B_5		
	C_1,C_2,D_1		
With mitigation	A_1,B_3,C_1,C_2	A_2,B_2,D_1	A_3,A_4 2/, B_1
			B_4,B_5 3/
			E_1

1. The following is a summarization of the various alternatives to facilitate review of Table 1.

   Alternative A - More flow over Fremont Weir.

   A_1 - sediment removal in front and behind weir
   A_2 - change weir crest elevation
   A_3 - set back Yolo Bypass levees
   A_4 - any combination of the above

   Alternative B - Modify Sacramento Weir.

   B_1 - modify gate operations
   B_2 - modify weir
   B_3 - sediment removal upstream/downstream of weir
   B_4 - set back Sacramento Bypass levees
   B_5 - any combination of the above

TABLE 1 - CONTINUED

Alternative C - Use of Sacramento River Deep Water Ship Channel.

C_1 - construct additional levees along the Ship Channel and pump water from the Sacramento River and/or Yolo Bypass

C_2 - construct facility to divert Sacramento River or Yolo Bypass water into the Ship Channel

Alternative D - Levee modifications.

D_1 - raise and widen West Sacramento levees in some locations, east and west Yolo Bypass levees, and south cross levee

Alternative E - Expand Yolo Bypass Capacity at Interstate 80 and Southern Pacific Railroad tracks.

E_1 - remove embankment materials under I-80 and SP tracks

2. For this rating we assumed that the combination would be limited to those options favorable for fish and wildlife resources, e.g., A_3 and A_4.

3. Same assumption as above, e.g., B_1, B_2, and B_4.

MITIGATION AND ENHANCEMENT OPPORTUNITIES

To assess mitigation needs for aquatic habitat impacts along the Sacramento River, we selected anadromous fish (four races of chinook salmon, steelhead trout, striped bass, American shad and green and white sturgeon) as our evaluation species. These species were selected because they are likely to be impacted and exhibit sensitivity to the flood control project alternatives. The habitat in the Sacramento River is of high value for these evaluation species because it serves as a migratory corridor for adults to reach upstream spawning grounds and a corridor for juveniles to return to the ocean. The corridor is irreplaceable in this ecoregion. Without the corridor, anadromous fish runs would quickly diminish.

The Yolo and Sacramento Bypasses likely serve as fish passage corridors and seasonal habitat for juvenile and adult anadromous species. No information is available on the numbers of fish and/or how long they stay in the bypasses. Our primary goal with respect to anadromous fish and the bypasses is to prevent diversion of fish into the bypasses, thus reducing their chance for survival in their upstream or downstream migration and to improve their egress from the bypasses.

To assess mitigation needs for aquatic impacts in the various lakes, ponds, canals, and other waterways in the project area, we selected catfish,

crappie and bluegill as our evaluation species because they are common to the waterways, likely to be impacted, and sensitive to the flood control alternatives. We consider the aquatic habitat in the waterways to be of high to medium value for these evaluation species and relatively abundant on a national basis. Our mitigation goal for the aquatic habitat is no net loss of habitat value while minimizing loss of in-kind habitat value.
We selected riparian forest dependent resident and migratory passerine birds, raptors, and mammals as evaluation species for mixed riparian forest habitat. The mixed riparian forest habitat is considered to be of high value for the evaluation species because it is unique and irreplaceable in this ecoregion.

Bank swallow, rough winged swallow, and belted kingfisher were selected as evaluation species for vertical bank habitat. Because the number of vertical banks in the Sacramento River have declined and are scarce in the project area, it is important to protect those remaining. Therefore, our mitigation goal is no net loss of in-kind habitat value.

Although the valley grassland supports fewer wildlife species than some other types of habitat, nonetheless it is important to many species. We selected the short-eared owl, western meadowlark, red-tailed hawk, coyote, black-tailed jackrabbit, and pheasant as our evaluation species. Valley grassland habitat is of high to medium value for the above evaluation species and is relatively abundant in the project area. Therefore, our mitigation goal is no net loss of habitat value while minimizing loss of in-kind habitat value.

Valley oak woodland supports many wildlife species. Mature oak trees are becoming scarce with urban sprawl and intensive farming practices. Preservation of oak woodland habitat is becoming more important as development progresses.

The white breasted nuthatch, western gray squirrel, great horned owl, and common flicker were selected as evaluation species for this habitat. We believe that valley oak woodland is of high value for these evaluation species and is relatively scarce in the ecoregion and project area. Our mitigation goal is not loss of in-kind habitat value.

Willow scrub is often the only wildlife habitat remaining in intensively farmed areas. In the Yolo Bypass, it is common to see small willow scrub outcroppings adjacent to ditches, canals, sinks, and along levees. Wildlife species often travel along distances to seek food and cover in willow scrub habitat.

We selected the western flycatcher, yellow warbler, and beaver as our evaluation species for assessing mitigation needs for willow scrub impacts; our goal is no net loss of in-kind habitat value.

Freshwater marsh is one of the most productive habitats for wildlife species. Because the permanent and seasonal freshwater marshes are already scarce, in the region and in California and of great value to wildlife, we take special efforts to protect them and, if possible, create additional marsh habitat.

The black-crowned night heron, northern harrier, red-wing blackbird, and marsh wren were selected as our evaluation species for freshwater marsh. Our mitigation goal for this habitat is no net loss of in-kind habitat.

Heavily-shaded riverine aquatic is a very specialized combination of riparian habitat located in and adjacent to water. Within the project area, most of this habitat type occurs along the Sacramento River, Tule Canal, and toe drains. Due to levee maintenance practices, much of the potential heavily-shade riverine aquatic along canals and ditches is burned or removed before it matures and provides shade. Our evaluation species for heavily-shaded riverine aquatic habitat are juvenile salmon, warmwater game fish, belted kingfisher, and black-crowned night heron. Due to its scarcity and value to wildlife, our goal is no net loss of in-kind habitat value.

Based on the our preliminary analysis of project alternatives and resourcce categorization, we recommend that the following mitigative measures be considered to minimize and offset any adverse impacts on fish and wildlife. Also, included are enhancement opportunities which can be considered in your investigation.

Alternative A

Selective depths and locations for sediment removal based on retention of established trees and other valuable areas would reduce adverse impacts of this option. Modification of the Fremont Weir crest should not proceed until adequate studies are completed to assess impacts of hydrological changes on fish and wildlife habitat and fish losses due to diversion. Some of this information may be obtained through further hydrological studies conducted by the Corps. It is possible that increased length of time that waters are present in the bypasses may improve migratory waterfowl habitat.

Levee setback offers great opportunity to improve wildlife habitat in the vicinity of the Fremont Weir and Yolo Bypass. Construction of a toe drain at a proper distance from the setback levee base, and designed to sustain healthy fish populations and support dense mixed riparian forest, scrub shrub, and heavily-shaded riverine aquatic habitat could mitigate for temporary levee construction impacts and existing levee maintenance practices. Retention of existing toe drains or interim retention until the newly constructed toe drain vegetation becomes established would reduce adverse impacts.

The setback levee concept would permit frequent maintenance of the levee, e.g., vegetation burning and brush removal by Reclamation Districts,

without diminishing fish and wildlife habitat value in the toe drains and old levees. Proper slope of construction the Yolo Bypass channel toward the toe drain and filling of depressions may reduce stranding losses of salmon during receding floodwater events.

Alternative B:

Modifying the Sacramento Weir to improve control of diversion flows into the Sacramento Bypass could be of benefit to wildlife. Operating the gates to minimize erosion and loss of vegetation in the Sacramento Bypass would reduce adverse impacts to existing wildlife habitat. As with the Yolo Bypass, retention of flow for a longer period in the Sacramento Bypass may improve opportunity for migratory waterfowl resting and feeding; however, the impacts on terrestrial habitat are unknown and therefore need to be studied further. Some of the information may be obtained indirectly through further hydrological studies conducted by the Corps.

Removal of gates and installation of a permanent weir would offer less flow control over waters in the Sacramento Bypass, thereby reducing the opportunity to regulate flow for fish and wildlife purposes.

As with the Yolo Bypass, selective excavation of sediment deposits within the Sacramento Bypass, while retaining important wildlife habitat, would reduce adverse impacts of this option. Minimizing construction work in and around established riparian vegetation along existing ditches, canals, and toe drains would also reduce adverse impacts.

Setting back the north levee of the Sacramento Bypass would result in fewer adverse impacts compared to the south levee. Construction of a new setback levee landward of the north levee and a toe drain at a proper distance from the levee would minimize adverse impacts. Revegetation of the new toe drain with native riparian species to develop additional mixed riparian forest habitat would benefit wildlife. The new levee and toe drain design should allow for optional levee maintenance without damage to wildlife habitat established with the new toe drain. Additional wildlife benefits could be gained by retaining the old levee and toe drains in place and allowing natural growth to occur. The new setback levee should be located to offset channel capacity lost due to the retention of the existing levee and toe drains in the Sacramento Bypass. Problems with off-road vehicles using berms in the Sacramento Bypass channels will need to be addressed with this option.

Alternative C: Use of the Sacramento River Deep Water Ship Channel.

Diversion and/or pumping floodwaters from either the Yolo Bypass or Sacramento River into the ship channel are not acceptable alternatives from an anadromous fishery perspective. Both of these alternatives represent an additional diversion of Sacramento River fish into a man-made channel which is not designed for fish habitation or migration. Either of these alternatives would probably cause a significant increase in losses of anadromous fish species, which are already severely impacted from other

actions, including pumping, diversions, pollution, etc. It would be difficult to assess exact number of fish loss and other adverse impacts due to the variability in timing, volume and length of flood occurrences. However, some estimates would be possible including a worst case analysis. These studies must be completed in order to assess the significance of adverse impacts on the fishery and to determine if there are acceptable mitigation measures.

Alternative D: Levee modifications along the West Sacramento, east and west Yolo Bypass and south cross levees.

As previously stated, raising and widening the West Sacramento levee in the vicinity of Raley's Landing will cause adverse impacts to terrestrial resources. Acquiring additional lands (fee title or easement) adjacent to the levee, revegetating, and managing them for wildlife would mitigate much of the adverse impacts. We understand that it will not be necessary to modify other levees downstream of Raley's Landing on the West Sacramento River side.

Avoidance of construction near the Tule Canal and toe drain, which runs parallel to the west Yolo Bypass from the Sacramento Bypass to the south cross levee, would greatly reduce any adverse aquatic impacts. Terrestrial impacts can be mitigated through revegetation of the area landward of the new levees with species similar to those now present, or by acquiring additional lands (fee title or easement) to be managed for wildlife purposes. Much of the lands adjacent to the west levees are upland farmed parcels with low wildlife value.

Avoidance of construction near the channel side toe drains of the East Yolo Bypass levee would greatly reduce aquatic and terrestrial resources, because much of the valuable habitat lies on the channel side of the levees. Although there are some emergent and scrub-shrub wetlands on the landward side adjacent to the levees, they are much smaller in area. Appropriate relocation and revegetation measures for the upland and wetlands on the landward side should adequately mitigate any losses.

In lieu of widening and raising both sides of the south cross levee, construction confined only to the north of the levee would significantly reduce project impacts. Similarly, new levee construction could be accomplished on the north side with less terrestrial impacts than on the south side. An alternative to this is to construct a new south cross levee at a significant distance from the existing one. This would minimize adverse impacts on the 15 or more acres of open water and associated scrub-shrub habitat adjacent to the south cross levee. Impacts would be on active farmlands rather than wildlife habitat.

Alternative E: Expand Yolo Bypass Capacity at the Route 80 Causeway and Southern Pacific Railroad Tracks.

Expanding the Yolo Bypass capacity at the Route 80 Yolo Causeway would probably cause few adverse aquatic or terrestrial impacts and therefore

should require minimal mitigation. There are about 4.5 acres of scrub shrub wetland near the west end of the Yolo Causeway and 20 acres of scrub shrub wetland along the Southern Pacific railroad tracks. These areas should be avoided if possible. However, if wetland losses do occur, mitigation will be required.

Also, there may be some opportunity to enhance aquatic and terrestrial in the area habitat. They include: (1) improving flow conditions under the causeway to enhance fish passage, and (2) revegetating the east and west causeway and railroad abutments to improve wildlife habitat.

FISH AND WILDLIFE INFORMATION NEEDS

There is a definite lack of fish and wildlife information of the areas adjacent to and within the Yolo Bypass, Sacramento Bypass and Sacramento River Deep Water Ship Channel. Little is known about the impacts of existing flood control operation on fish and wildlife resources in the study area. As we stated earlier (see impacts section), some flood control alternatives without appropriate mitigation would have a major adverse impact on fish and wildlife habitat, i.e., pumping into the ship channel. Conversely, some of the flood control alternatives also offer opportunities to improve and enhance fish and wildlife habitat, i.e., setback levee with retention of existing levee. Providing better passage conditions for anadromous fish through the flood bypasses is another.

The comprehensive nature of many of the proposed flood control alternatives would require comprehensive inventory of fish and wildlife resources, detailed analysis of flood control operation alternative impacts on fish and wildlife, and a survey for the valley elderberry longhorn beetle. In addition, we recommend that surveys for the Federal candidate species California hibiscus, Sacramento perch, and Sacramento splittail also be done. Based on the Department of Fish and Game's June 21, 1988 report, we also recommend that surveys be done for the giant garter snake, Swainson's hawk, western yellow-billed cuckoo, and bank swallow. We would also need recent aerial photographs of the study area and data on any anticipated future development.

Based on these informational needs, we recommend the following studies be conducted during the project feasibility phase:

1. The Service's terrestrial and aquatic Habitat Evaluation Procedures for Alternatives, A, B, C, and D.

2. Surveys for the threatened valley elderberry longhorn beetle, California hibiscus, Sacramento splittail, Sacramento Perch, giant garter snake, Swainson's hawk, western yellow-billed cuckoo, and bank swallow.

3. Assessment of fishery resources in the toe drains, canals, borrow ditches and other ponds affected by the project alternatives.

4. Assessment of potential fish losses due to pumping into the ship channel.

5. Assessment of potential fish losses due to diversions from the Sacramento River into the flood bypasses and/or into the Ship Channel.

6. Analysis of existing and proposed flood control operations impacts on fish and wildlife habitat and populations.

7. Assessment of mitigation measures necessary to offset unavoidable project alternative impacts.

We appreciate the opportunity to provide input to your reconnaissance level study. If you have any questions regarding this letter, please contact Gary Taylor of my staff at (916) 978-4613.

Sincerely,

James D. Carson

James D. Carson
Acting Field Supervisor

Enclosure

cc: ARD (AFWE), FWS, Portland, OR
Dir., CDFG, Sacramento, CA
Reg. Mgr., Reg. II, CDFG, Rancho Cordova
NMFS, Santa Rosa (Jim Bybee, Environmental Coordinator)
CE-SAC-ENV.

Literature Cited

Hallock, R.J. 1987. Sacramento River system salmon and steelhead problems and enhancement opportunities. A report to the California Advisory Committee on Salmon and Steelhead Trout. Sacramento, California 92 pp.

Jones & Stokes Associates. 1987. Final environmental impact report and supplemental environmental impact statement IV. Sacramento River bank protection project. Prepared for the Reclamation Board, State of California and U.S. Army Engineer District, Sacramento, California.

Kjelson, M.A., P.F. Raquel, and F.W. Fisher. 1982. The life history of fall-run juvenile chinook salmon (*Oncorhynchus tshawytscha*) in the Sacramento-San Joaquin Estuary of California. California Department of Fish and Game. Sacramento, California. Unpublished report. 29 pp.

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Remsen, J. V., Jr. 1978. Bird species of special concern in California: an annotated list of declining or vulnerable bird species. (Wildlife Management Branch Administrative Report No. 78-1.) California Department of Fish and Game. Sacramento, California. 54 pp.

U.S. Bureau of Reclamation. 1986. Central Valley fish and wildlife management study. Temperature and flow studies for optimizing chinook salmon production, upper Sacramento River, California. Sacramento, California. 120 pp.

United States Department of the Interior

FISH AND WILDLIFE SERVICE

SACRAMENTO ENDANGERED SPECIES OFFICE
2800 Cottage Way, Room E-1823
Sacramento, California 95825-1846

JUN 17 1988

In Reply Refer To:
NRK/1-1-88-SP-495

Mr. Walter Yep
Chief, Planning Division
Environmental Resources Branch
U.S. Army Corps of Engineers
650 Capitol Mall
Sacramento, California 95814-4794

Subject: List of Endangered, Threatened, and Candidate Species in the Vicinity of the Northern California Streams Sacramento Metropolitan Area Project

Dear Mr. Yep:

As requested by letter from your agency dated May 24, 1988, you will find attached a list of endangered and threatened species (Attachment A) that may be present in the area of the subject project. To the best of our knowledge no proposed species occur within the area. The list fulfills the requirement of the Fish and Wildlife Service to provide a list of species under Section 7(c) of the Endangered Species Act, as amended. Please see Attachment B for your requirements.

Also, for your assistance, we have included a list of candidate species. These species are presently being reviewed by our Service for consideration to propose and list as endangered or threatened. Candidate species have no protection under the Endangered Species Act and are included for your consideration as it is possible they could become formal proposals and be listed during the construction period. Should the assessment reveal that candidate species may be adversely affected, then you should consider requesting technical assistance from our office. One of the benefits of technical assistance to the consulting agency is to provide the necessary planning alternatives should a candidate species become listed before completion of a project.

Upon completion of the Biological Assessment (see Attachment B), should you determine that a listed species may be affected (adversely or beneficially), then your agency should request formal Section 7 consultation, pursuant to 50 CFR § 402.14

cc: Field Supervisor, Ecological Services, Sacramento, CA

through our office. Informal consultation may also be utilized prior to a written request for formal consultation to exchange information and resolve conflicts with respect to listed species. If the Biological Assessment is not initiated within 90 days of receipt of this letter, you should informally verify the accuracy of the list with our office.

Should you have any additional questions regarding this list or your responsibilities under the Act, please contact Mr. David Harlow at (916) 978-4866 or (FTS) 460-4866. Thank you for your interest in endangered species, and we await your assessment.

Sincerely,

Gail C. Kobetich

Gail C. Kobetich
Field Supervisor

Attachments

cc: Chief, Endangered Species, Portland, Oregon (FWE-SE; Attn: Ralph Swanson)
/Field Supervisor, Ecological Services, Sacramento, California (ES-S)

ATTACHMENT A

LISTED AND PROPOSED ENDANGERED AND THREATENED SPECIES AND CANDIDATE SPECIES THAT MAY OCCUR IN THE AREA OF THE PROPOSED NORTHERN CALIFORNIA STREAMS SACRAMENTO METROPOLITAN AREA PROJECT (Case No. 1-1-88-SP-495)

Listed Species

valley elderberry longhorn beetle (*Desmocerus californicus dimorphus*) (T)

Proposed Species

None

Candidate Species

Sacramento perch (Sacramento Valley population) (*Archoplites interruptus*) (R2)
California hibiscus (*Hibiscus californicus*) (2)
Sacramento splittail (*Pogonichthys macrolepidotus*) (R2)

(E)--Endangered (T)--Threatened (CH)--Critical Habitat
(1)--Category 1: Taxa for which the Fish and Wildlife Service has sufficient biological information to support a proposal to list as endangered or threatened.
(2)--Category 2: Taxa for which existing information indicated may warrant listing, but for which substantial biological information to support a proposed rule is lacking.
(R2)--Recommended addition to Category 2

ATTACHMENT B

FEDERAL AGENCIES' RESPONSIBILITIES UNDER SECTIONS 7(a) and (c) OF THE ENDANGERED SPECIES ACT

SECTION 7(a) Consultation/Conference

Requires: 1) Federal agencies to utilize their authorities to carry out programs to conserve endangered and threatened species; 2) Consultation with FWS when a Federal action may affect a listed endangered or threatened species to insure that any action authorized, funded or carried out by a Federal agency is not likely to jeopardize the continued existence of listed species or result in the destruction or adverse modification of critical habitat. The process is initiated by the Federal agency after determining the action may affect a listed species; and 3) Conference with FWS when a Federal action is likely to jeopardize the continued existence of a proposed species or result in destruction or adverse modification of proposed critical habitat.

SECTION 7(c) Biological Assessment--Major Construction Activity[1]

Requires Federal agencies or their designees to prepare a Biological Assessment (BA) for major construction activities. The BA analyzes the effects of the action[2] on listed and proposed species. The process begins with a Federal agency requesting from FWS a list of proposed and listed threatened and endangered species. The BA should be completed within 180 days after its initiation (or within such a time period as is mutually agreeable). If the BA is not initiated within 90 days of receipt of the list, the accuracy of the species list should be informally verified with our Service. No irreversible commitment of resources is to be made during the BA process which would foreclose reasonable and prudent alternatives to protect endangered species. Planning, design, and administrative actions may proceed; however, no construction may begin.

We recommend the following for inclusion in the BA: an on-site inspection of the area affected by the proposal which may include a detailed survey of the area to determine if the species or suitable habitat are present; a review of literature and

---

[1]A construction project (or other undertaking having similar physical impacts) which is a major Federal action significantly affecting the quality of the human environment as referred to in NEPA (42 U.S.C. 4332(2)C).

[2]"Effects of the action" refers to the direct and indirect effects on an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action.

TO: Defense Technical Information Center
ATTN: DTIC-O
8725 John J. Kingman Road, Suite 0944
Fort Belvoir VA 22060-6218

22 October 2008

FROM: US Army Corps of Engineers
Sacramento District Library
1325 J Street, Suite 820
Sacramento CA 95814-2292

SUBJECT: Submission of technical reports for inclusion in Technical Reports Database

The enclosed documents from USACE Sacramento District are hereby submitted for inclusion in DTIC's technical reports database. The following is a list of documents included in this shipment:

ADB344304 • Lemon Reservoir Florida River, Colorado. Report on reservoir regulation for flood control, July 1974
ADB344333 • Reconnaissance report Sacramento Metropolitan Area, California, February 1989
ADB344346 • New Hogan Dam and Lake, Calaveras River, California. Water Control Manual Appendix III to Master Water Control Manual San Joaquin River Basin, California, July 1983
ADB344307 • Special Flood Hazard Study Nephi, Utah, November 1998 (cataloged)
ADB344344 • Special Study on the Lower American River, California, Prepared for US Bureau of Reclamation – Mid Pacific Region and California Dept. of Water Resources..., March 1987
ADB344313 Transcript of public meeting Caliente Creek stream group investigation, California, held by, the Kern County Water Agency in Lamont, California, 9 July 1979
ADB344302 • Initial appraisal Sacramento River Flood control project (Glenn-Colusa), California, 10 February 1989
ADB344485 • Report on November-December 1950 floods Sacramento-San Joaquin river basins, California and Truckee, Carson, and Walker rivers, California and Nevada, March 1951
ADB344268 • Reexamination Little Dell Lake, Utah, February 1984
ADB344197 • Special report fish and wildlife plan Sacramento River bank protection project, California, first phase, July 1979
ADB344264 • Programmatic environmental impact statement/environmental impact report Sacramento River flood control system evaluation, phases II-V, May 1992
ADB344201 • Hydrology office report Kern river, California, January 1979
ADB344198 • Kern River – California aqueduct intertie, Kern county, California, environmental statement, February 1974
ADB344213 • Sacramento river Chico Landing to Red Bluff, California, bank protection project, final environmental statement, January 1975
ADB344265 • Cottonwood Creek, California, Information brochure on selected project plan, June 1982
ADB344261 • Sacramento river flood control project Colusa Trough Drainage Canal, California, office report, March 1993
ADB344343 • Detailed project report on Kern River-California aqueduct intertie, Kern County, California, February 1974

ADB344267 • Sacramento River Flood Control Project, California, Right Bank Yolo Bypass and Left Bank Cache Slough near Junction Yolo Bypass and Cache Slough, Levee construction, General Design, Supplement No. 1 to Design Memorandum #13, May 1986

ADB344246 • Redbank and Fancher Creeks, California, General Design Memorandum #1, February 1986

ADB344260 • Cache Creek Basin, California, Feasibility report and environmental statement for water resources development Lake and Yolo counties, California, February 1979

ADB344199 • Sacramento River Deep Water Ship channel, California, Feasibility report and environmental impact statement for navigation and related purposes, July 1980

ADB344263 • Sacramento River flood control project, California, Mid-Valley area, phase III, Design Memorandum, Vol. I or II, June 1986

ADB344262 • Marysville Lake, Yuba River, California, General Design Memorandum Phase I, Plan Formulation, Preliminary Report, Appendixes A-N, Design Memorandum #3, March 1977

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